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# Structural Change and Poverty Reduction in Brazil: The Impact of the Doha Round

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**Abstract**. Over the medium time horizon, skill upgrading, differentials in sectoral technological progress, and migration of labor out of farming activities are some of the major structural adjustment factors shaping the evolution of an economy and its connected poverty trends. Our main focus is understanding, for the case of Brazil, how a trade shock interacts with these structural forces and ascertaining whether it enhances or hinders medium-term poverty reduction. In particular, we consider the interactions between the migration of labor out of agriculture, a potentially important poverty reduction factor, and trade liberalization, which increases the price incentives to stay in agriculture. A recursive-dynamic computable general equilibrium model simulates Doha scenarios and compares them against a Business as Usual scenario. The poverty effects are estimated using a microsimulation model that primarily takes into account individuals' labor supply decisions. Our analysis shows that trade liberalization does indeed contribute to *structural* poverty reduction. However, unless increased productivity and stronger growth rates are attributed to trade reform, its contribution to medium term poverty reduction is rather small.

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## 1 Introduction

The long-term trend of shrinking agriculture employment and expanding employment in the secondary or tertiary sectors has been associated with economic development. And, since moving out of agriculture and getting a job in the non farm segment normally means earning higher incomes, this type of intersectoral migration should also lead to lower poverty rates. In recent years, Brazil, as many other developing countries, has experienced a significant reduction of its agricultural employment and there is indirect evidence that this migration out of agriculture is poverty reducing. Establishing more direct evidence is difficult mainly because of lack of data reporting the characteristics of migrants at the time of moving, a limitation that affects (sometimes with intractable endogeneity issues) a lot of migration models. This paper, relying on a special section of the Brazilian household survey that chronicles individuals' past employment, offers, for the case of Brazil, a direct assessment of how much poverty reduction can be attributed to these intersectoral labor movements. By estimating a mover-stayer model using Brazilian micro data, we can identify the main factors affecting the propensity of moving out of agriculture and rank individuals accordingly. The estimations show that individuals that are most likely to migrate are found among the poorer, often landless heads of households, but also among the better educated, and thus less poor, non-head household members. Overall though, we observe, and this is one key finding of the paper, that movers experience the highest poverty reduction when compared to both agricultural and non-agricultural stayers.

This confirms that changes in sectoral employment can significantly contribute to poverty reduction. Chronic poverty is often linked to the difficulty of finding employment in a better paid job in a growing sector. There is mounting evidence of the existence of poverty traps characterized by situations where occupational or technology choices are discrete, and where choosing a higher return occupation or technology implies large sunk or fixed costs (Barrett 2004). Moving out of agriculture, where poverty rates are often much higher than in other sectors, is one example of such choices.

Our intersectoral migration estimations rely on past data, however by embedding the mover-stayer model within a more complete income generation microsimulation approach we can model occupational dynamics and test (or simulate) some relevant hypotheses (scenarios). Our focus is on global trade liberalization. Recent studies show that a major effect of global liberalization is to raise prices of agricultural commodities and thus to increase labor demand in agriculture. This in turn raises agricultural wages and reduces a major incentive to migrate to non-farm jobs. We then ask whether global trade liberalization, by decreasing inter-sectoral migration, would have an adverse impact on poverty reduction. By contrast, by reducing the inflows of agricultural workers searching for jobs, it may relieve some of the pressure on incomes in the non-agriculture sectors, or even have some direct poverty reducing effect through raising agricultural incomes (that more than compensates for lower migration flows). For the case of Brazil, we find that trade liberalization scenarios can significantly reduce the flow of workers out of agriculture but that the net final effect is that more individuals, rather than less as initially hypothesized, are able to escape poverty.

To resolve the ambiguity of the poverty impacts of trade reform we rely on the mentioned microsimulation approach and combine it with a recursive dynamic computable general equilibrium (CGE) model. In a first step, we build a Business as Usual (BaU) scenario that 'replicates' for a 15 year future period the main economic trends – including changes in the skill composition of the population and in the sectoral distribution of employment – observed in the recent decade. We then simulate, for the same time horizon, counterfactuals involving trade reforms and link key CGE's aggregate results (on relative factor prices and resource movements from agricultural to non-agricultural sectors) to the microsimulation model. This is finally used to estimate new counterfactuals income distributions and poverty and inequality statistics can be calculated and compared with those of the BaU scenario.

This macro-micro model enables us to analyze the long-term poverty and distributional impact of the different growth patterns implied by trade liberalization scenarios versus a Bau scenario, but can potentially be used to study other policies as well. Among the additional key findings, our approach demonstrates that, at least for high inequality countries such as Brazil, anti-poor changes in the distribution can easily dwarf the poverty reducing potential of growth and that successful poverty reduction strategies need to include re-distribution or precise targeting measures. This confirms what, in different contexts, recent research has also shown: growth can differ tremendously in its power to reduce poverty both across countries and over time;[1] according to Bourguignon (2003) changes in per capita incomes only explain, at least in his large sample of countries, 26% of the variance of observed changes in poverty headcounts.

[1] See Bourguignon (2004), Ravallion (2001), Ravallion and Datt (1999), World Bank (2001), or Kappel, Lay and Steiner (2005).

The paper is structured as follows. The next section provides some background information on the Brazilian case and motivates our approach. Section 3 describes the macro and micro models. The results of our simulations are reported and commented in section 4. The last section summarizes and concludes.

## 2 Background and Motivation

The main objective of this paper is to assess whether trade reform favors the Brazilian poor. It is therefore important to know who the poor are, where they live, and especially how they earn their living. In addition, it should prove helpful to identify economic trends that have been particularly important for the poor.

Brazil's per capita income has virtually stagnated for the past 25 years and the very unequal distribution of income has remained more or less unchanged. Accordingly, poverty in Brazil has been roughly constant over the past 25 years (Bourguignon, Ferreira, and Lustig 2005; Verner 2004). In light of the substantial structural changes that have occurred in this period, especially increasing urbanization, a massive decline in agricultural employment, an important educational expansion and demographic changes, this appears "paradoxical", as Bourguignon et al. (2005) put it. Yet, microsimulation exercises by Ferreira and Paes de Barros (2005) show that each of the features of structural change affects poverty and inequality, but they tend to cancel out each other.[2]

Notwithstanding its considerable variation across multiple dimensions, poverty in Brazil is particularly high in rural areas, small and medium towns and the metropolitan peripheries of the North and the Northeast (Ferreira, Lanjouw, and Neri 2001). In 1996, the North and the Northeast accounted for 55 percent of the poor and for 34 percent of the Brazilian population. At the national level, about 20 percent of the population lived in rural areas contributing 35 percent to total poverty.[3] The high poverty rates in rural areas, particularly in the Northeast, are related to this region's predominance of employment in agriculture. The Northeast has the highest share of agriculture in employment with 34 percent in 2001 compared to only 11.5 percent in the Southeast.[4] According to Ferreira,

[2] Note that their analysis compares the income distribution of 1976 with the 1996 distribution. For detailed results see Ferreira and Paes de Barros (2005).

[3] Poverty is measured by the headcount ratio. The poverty figures in this paragraph are taken from Ferreira, Lanjouw, and Neri (2001).

[4] The figures on agricultural employment are own calculations based on the PNAD 1997 and the PNAD 2001. The PNAD (Pesquisa Nacional por Amostra de Domicílios) is a regularly conducted representative household survey. The sample had a size of about 380 000 individuals in 2001.

Lanjouw, and Neri (2001), 20 percent of all households had a household head employed in agriculture and these households contributed 34 percent to overall poverty in 1996.

Changes in poverty, not only its levels, also differ across regions, rural and urban areas, and activities. Verner's (2004) PNAD (Pesquisa Nacional por Amostra de Domicílios)-based figures suggest that the poverty headcount in the Northeast declined from almost 60 percent in 1990 to 42.3 percent in 2001, whereas poverty in Brazil's most populous state São Paulo rose slightly from 8.6 to 9.4 percent during the same period. For urban areas, Ferreira and Paes de Barros (2005) show that extreme poverty increased between 1976 and 1996. According to Paes de Barros (2004) however, the poverty incidence in rural areas in general and among households engaged in agricultural activities, in particular, declined from levels of about 60 percent to around 50 percent between 1992 and 2001.

One important factor for understanding these developments is the structural change in Brazilian agriculture in the 1980s and 1990s. In their assessment of the impact of sector-specific as well as economy-wide reforms on Brazilian agriculture, Helfand and Rezende (2004) conclude that agriculture became one of the most dynamic sectors in the Brazilian economy. Between 1980 and 1998 real GDP grew by about 40 percent and real agricultural output by about 70 percent. In many sub-sectors, yields increased significantly and more harvested area was dedicated to exportables, in particular soybeans and sugarcane. Agriculture benefited from favorable macroeconomic environment and trade reforms that led to less industrial protection and the elimination of taxes and quantitative restrictions on agricultural exports. In addition, specific agricultural reforms – in particular a reform of agricultural credit and price support policies; an agrarian reform program, including a land reform; and, finally, the deregulation of domestic markets for agricultural goods – were important drivers of the observed agricultural performance.[5]

However, the increase in agricultural productivity was accompanied by a massive lay-off of hired labor and by important changes in the size distribution of farms. According to the agricultural census from 1996, the number of small farms declined dramatically and agricultural employment shrank by 23 percent between 1986 and 1996, although these figures should be taken with some caution (Helfand and Rezende 2004). Our analysis based on the 1997 and 2001 household surveys (PNAD) suggests that this decline in agricultural employment has continued after 1996. In 2001, agriculture accounted for 20.6 percent of employment in Brazil down from 24.2 percent in 1997.

[5] See Helfand and Rezende (2004) and Dias and Amaral (2002) for details.

Non-agricultural activities appear to have compensated for the loss in agricultural employment in rural areas, but unemployment rates in urban areas with a previously important share of agricultural labor have risen in that period (Dias and Amaral 2002). Between 1997 and 2001, overall urban unemployment has risen from 9.44 to 10.6 percent, an increase that may be related to the decline in agricultural employment.[6]

Less agricultural employment opportunities may also be one of the reasons for further urbanization in Brazil although it is difficult to establish this link empirically, as we explain in more detail later. The rural population declined quite dramatically from 24 percent in 1991 to 22 percent in 1996 (IBGE 1997) and 16 percent in 2001 (PNAD 2001). The trends in rural poverty mentioned above suggest that the described developments have improved rural livelihoods. Nevertheless, poverty rates in rural areas remain well above urban poverty rates.

Future developments in agriculture are not known with certainty, but it is likely that some of the observed trends, in particular the decline in agricultural employment and the related, though very small, increase in incomes from agriculture, will continue. These future developments form thus the basis for our Business as Usual (BaU) scenario which provides an initial ex-ante quantitative analysis of the forthcoming changes in poverty and income distribution.

So far, we have been mainly concerned with the rural poor and the developments in the agricultural sector. However, more than two thirds of the Brazilian poor either live in urban areas or from income earned in non-agricultural sectors. Our analysis explicitly considers how wages and employment in the non-farm sectors, the main income sources for the urban poor, are affected by the migration flow out of agriculture and by the education upgrading, but other factors are admittedly excluded. In particular, Ferreira and Paes de Barros (2005) find the increase in extreme poverty in urban Brazil to be related to rising unemployment and informality. Elbers, Lanjouw, Lanjouw and Leite (2004) report that the poverty incidence among informal sector employees and the urban self-employed is almost as high as among rural self-employed. In addition, educational expansion has been identified as a major tool in the fight against urban poverty and, for good reasons, it has become a major policy focus of the Brazilian government.[7]

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[6] Data from employment histories in the PNAD reveal that in both 1997 and 2001 about 6 percent of those who became unemployed in the last year were employed in agricultural sectors before. Taking into account that approx. 20 percent of the workforce are employed in agriculture, this figure is rather low and may be taken as a sign that the rise in urban unemployment is not causally linked to the decline in agricultural employment.

[7] The Bolsa Escola Program, a means-tested conditional cash transfer program that reaches 6 million households in Brazil, is one of the major policy instruments in this regard. See Bourguignon, Ferreira and Leite (2002) for an assessment of Bolsa Escola using a microsimulation model.

# 3 The Modeling Framework

The model consists of a sequentially dynamic CGE model that is linked to a microsimulation. The microsimulation takes the changes in factor and goods prices as given; hence, there is no feedback between these two parts of the model. We consider this framework particularly suited for the questions at hand, as the CGE model captures some of the main features of structural change and the relative price changes accompanying them. The microsimulation then allows for a detailed empirical assessment of the household responses to these changes. One of the major advantages of the microsimulation is that its unit of observation is the individual rather than the household, thereby offering a much richer representation of distributional dynamics.

## 3.1 The Macro Model

A 1997 Social Accounting Matrix (SAM) has been used as the initial benchmark equilibrium for the CGE model. This SAM has been assembled from various sources incorporating data from the 1997 Input Output table, information from the SAM assembled by Harrison, Rutherford, Tarr, and Gurgel (2003), and the 1997 and 2001 PNAD household surveys. For the purposes of this model the full SAM – which includes 41 sectors, 41 commodities, 12 factors (skilled and unskilled labor by gender and by farm and non-farm occupation, agricultural and non-agricultural capital, land and natural resources), an aggregate household account, and other accounts (government, savings and investment, and rest of the world)[8] – has been aggregated to a smaller size and it comprises the accounts shown in Table 1.

*Table 1: CGE Model accounts*

| | | |
|---|---|---|
| **Model Sectors** | | |
| 1 CerealGrains | 7 OilMinerals | 13 MachineryEquipment |
| 2 OilSeeds | 8 LightManufacturing | 14 OtherServices |
| 3 RawSugar | 9 AgriIndustriesExp | 15 Construction |
| 4 OthCrops | 10 WoodProductsPaper | 16 TradeCommunication |
| 5 Livestock | 11 ChemicalsOilPr | 17 PublicServices |
| 6 RawAnimalProducts | 12 MetalMineralProducts | |
| **Factors of Production** | | |
| 18 Land | 20 Capital | 22 Non agriculture Unskil. Lab |
| 19 Natural Resources | 21 Skilled Labor | 23 Agriculture Unskil. Lab |
| **Other Accounts** | | |
| 24 Production Taxes | 28 Direct Taxes | 31 Investment-Savings |
| 25 Indirect Taxes | 29 Households | 32 Variation of Stocks |
| 26 Tariffs | 30 Government | 33 Rest of the World |
| 27 Export Taxes | | |

[8] See annex for a full list of accounts.

The CGE model is based on a standard neoclassical dynamic general equilibrium model and the following subsections describe its main features. Given our focus on labor markets and dynamic structural trends, more detailed explanations are provided on the modeling of factor markets and growth.

*Production*. Output results from nested CES (Constant Elasticity of Substitution) functions that, at the top level, combine intermediate and value added aggregates. At the second level, on the one hand, the intermediate aggregate is obtained combining all products in fixed proportions (Leontief structure), and, on the other hand, value added results by aggregating the primary factors. At this level, primary factors are a capital-labor bundle and aggregate land. Lower levels disaggregate capital and labor, and then labor into different categories. The full nesting structure is presented in the annex in Figure 4.

*Income Distribution and Absorption*. Labor income and capital revenues are allocated to households according to a fixed coefficient distribution matrix derived from the original SAM. Notice that one of the main advantages of using the micro-module is to enrich, as described above, this rather crude macro distribution mechanism. Private consumption demand is obtained through maximization of household specific utility function following the Linear Expenditure System (LES). Private savings are a fixed proportion of income. Once the total value of private consumption is determined, government and investment demands[9] are disaggregated in sectoral demands according to fixed coefficient functions.

*International Trade*. The model assumes imperfect substitution among goods originating in different geographical areas.[10] Imports demand results from a CES aggregation function of domestic and imported goods. Export supply is symmetrically modeled as a Constant Elasticity of Transformation (CET) function. Producers decide to allocate their output to domestic or foreign markets responding to relative prices. The assumptions of imperfect substitution and imperfect transformability grant a certain degree of autonomy of domestic prices with respect to foreign prices and prevent the model from generating corner solutions. This single country Brazilian model has been linked to a global CGE model by adding export demand functions so that the increased market access

[9] Aggregate investment is set equal to aggregate savings, while aggregate government expenditures are exogenously fixed.

[10] See Armington (1969) for details.

accompanying multilateral trade liberalization scenarios can be simulated more precisely. In particular, for each export *k*, export demand has been implemented using a constant elasticity function, as shown in equation (1). With a finite elasticity, $\eta_k$, demand decreases as the price of exports, $WPE_k$, increases. The numerator contains an exogenous export price competitive index. If the latter increases relative to the domestic export price, market share of the domestic exporter would increase. During a trade policy simulation, to mimic the quantity and price shocks resulting from the global model, both the intercept, $\alpha_k$, and the price competitive index, *WPEindex*, are changed accordingly.

$$ED_k = \alpha_k \left( \frac{\overline{WPEindex}_k}{WPE_k} \right)^{\eta_k} \tag{1}$$

No international import supply functions have been added and Brazil is a price taker for its imports. The balance of payments equilibrium is determined by the equality of foreign savings (which are exogenous) to the value of the current account.

*Factor Markets.* Two types of labor are distinguished, skilled and unskilled. These categories are considered imperfectly substitutable inputs in the production process. Moreover, some degree of factor market segmentation is assumed: capital and land are perfectly mobile across sectors, natural resources are sector specific, and labor markets for the unskilled are segmented between agriculture and non-agriculture, whereas skilled workers are fully mobile.

The labor market specification is a key element of our model and an important driver of poverty and distributional results. Therefore, its specification calls for some clarification and justification. The labor market skill segmentation[11] has become a standard assumption in CGE modeling and it is easily justifiable for the case of Brazil. The inequalities of its society in terms of educational endowments and, more importantly, access to education and on-the-job training, certainly support this assumption even over medium-term time horizons.

The assumption that the market for unskilled labor is further segmented into agricultural and non-agricultural activities is more controversial. To test its validity, we check whether incomes in agriculture are still below incomes in other sectors once the following wage determinants are controlled for: education, experience, gender, racial dummies, employment-status variables, such as self-employment, being employed in the

[11] See Taubman and Wachter (1986) for a general discussion of labor market segmentation.

informal sector, or working only seasonally. Additionally and to take into account price differentials across space, geographical variables capturing differences among Brazilian regions, and a rural/urban dummy are included in the wage estimation. Taking the largest non-agricultural sector in terms of employment, "other services", as a reference group, a regression analysis shows that agricultural individual labor incomes are significantly below this reference group.[12]

There can be a number of reasons for observing this income gap between agricultural and non-agricultural employment. A first explanation could be that agricultural income, in particular from self-employment, is systematically underreported. Yet, the regression results suggest that there is no underreporting problem for the self-employed, as for example both the dummy for self-employment and the dummy for being a landowner[13] turn out to be significantly positive. It can be argued at this point that these dummies reflect the returns to land, and underreporting may still be present. Even if so, we also do not see a reason why there should be systematically more underreporting among the wage-employed in agricultural than among those in non-agricultural sectors.

Another reason for the sectoral income differential may lie in positive externalities associated to agricultural employment. Examples of such externalities include food self-sufficiency or employment opportunities for other family members. Yet, one can also easily think of negative externalities of agricultural employment, such as the exposure to weather shocks or hard physical work. These externalities are difficult if not impossible to quantify.

If we accept that there is an income differential between agriculture and non-agricultural sectors, the question then becomes why individuals do not respond to this differential and move to the non-agricultural sector until incomes in both sectors are equalized. A likely answer is that there must be barriers to mobility between agricultural and non-agricultural employment and that these barriers are relevant for the time period of our analysis. A very important factor that may represent a barrier to mobility in the medium run is land ownership in the agricultural sector. Smallholders owning their own land and non-remunerated family members on these farms account for approximately 40 percent of agricultural employment in Brazil. There may be important externalities related to land ownership, such as economic independency. Some smallholders may not sell the land they own because of a bequest motive. Another important barrier is represented by the

[12] This is the case for all agricultural sectors except the oil seeds and the sugar cane sector, which account for approximately 6 percent of agricultural employment. The regression results are reported in appendix 7.3, where it is also possible to note that labor incomes in all non-agricultural sectors, with the notable exception of agricultural processing, are significantly higher than in "other services".

[13] More than 60 percent of the agricultural self-employed work on their own land.

specificity of human capital acquired in the agricultural sector. In addition, risk aversion may also prevent people from switching from agricultural to non-agricultural activities since they will only on average gain more in non-agricultural sectors. The estimations for our microsimulation model, commented in more detail, here below lend empirical support to some of these hypotheses. In particular, land ownership appears to prevent individuals from moving out of the agricultural sector.

The implementation of dual labor markets for *unskilled* workers approximates the standard Harris-Todaro specification where the decision to migrate is a function of the expected income in the non agricultural (urban, in the original formulation) segment relative to the expected income in the agricultural (rural) segment. The specification deviates somewhat from Harris-Todaro. First, relative wages are used as a proxy for relative incomes. Second, actual wages determines migration rather than expected wages in the absence of unemployment. The basic migration equation has the form given in equation (2), where *MIGR* represents the level of migration between segments. Note that the index *l* indicates the skill level (*l* = unskilled), the index *g* represent the segment (*g* = agriculture or non-agriculture), and index *i* is for the sectors.

$$MIGR_l = \chi_l^m \left[ \left( \frac{AWAGE_{Nagri,l}}{AWAGE_{Agri,l}} \right)^{\omega_l^m} - 1 \right] \tag{2}$$

$$AWAGE_{g,l} = \frac{\sum_{i \in g} \left( \frac{W_{i,l}}{1+\tau_{i,l}^{fl}} \right) L_{i,l}^d}{\sum_{i \in g} L_{i,l}^d} \tag{3}$$

The variable *AWAGE* is the average wage in the respective segments and is given by equation (3). The average wage is a weighted average using, as weights, the employment levels for all the sectors of each segment and the net-of-tax wage rates, the rates which matter to the worker deciding to migrate or not.
Labor market equilibrium conditions are based on two separate labor markets rather than the integrated market of the skilled workers. Equation (4) determines the equilibrium wage rate by segment—i.e. agriculture and non-agriculture. It sets the aggregate segment labor supply equal to the demand for labor in the same segment, i.e. it determines the variable $W^e$ which is now indexed by both segment index as well as labor type.

$$L^s_{g,l} = \sum_{i \in g} L^d_{i,l} \tag{4}$$

Within each segment, the model allows for inter-sectoral wage differentials, but these are exogenous in the standard model. Equation (5) evaluates the relative wages with respect to the segment-specific equilibrium wage.

$$W_{i,l} = \phi^l_{i,l} W^e_{g,l} \quad \text{for} \quad i \in g \tag{5}$$

The remaining loose end is the definition of labor supply and this is given by equations (6) and (7). It is assumed that labor supply net of migration is given in any given period. In the dynamic scenario, labor supply in each segment grows at the same exogenous rate, $g^L$ and migration is subtracted from this amount in the agricultural segment, equation (6), and is added to labor supply in the non-agricultural segment, equation (7). Equation (8) determines the total economy-wide labor supply for each labor type.

$$L^s_{Agri,l} = \left(1 + g^L_l\right) L^s_{Agri,l,-1} - MIGR_l \tag{6}$$

$$L^s_{Nagri,l} = \left(1 + g^L_l\right) L^s_{Nagri,l,-1} + MIGR_l \tag{7}$$

$$L^s_{Tot,l} = L^s_{Agri,l} + L^s_{Nagri,l} \tag{8}$$

*Model Closures*. The equilibrium condition on the balance of payments is combined with other closure conditions so that the model can be solved for each period. Firstly consider the government budget. Its surplus is fixed and the household income tax schedule shifts in order to achieve the predetermined net government position. Secondly, investment must equal savings, which originate from households, corporations, government and rest of the world. Aggregate investment is set equal to aggregate savings, while aggregate government expenditures are exogenously fixed.

*Growth equations*. Sectoral shifts among agriculture and non-agriculture and human capital upgrading are two of the main features that have characterized recent growth processes in Brazil, and indeed in most developing nations. To capture these features in a transparent and simple dynamic framework, productivity growth calibration is different for the agriculture and non-agriculture sectors. Equation (9) defines the growth rate of

GDP at market price and equation (10) is a formula expressing a balanced growth, where capital to labor ratio in efficiency units is constant. In equation (10) $\lambda^k$ and $\lambda^l$ represent efficiency shifters for the capital and labor factors, *L* and *K*; $\chi^{kl}$ is the capital to labor ratio which is equal to the ratio calculated in the initial equilibrium (where the variables are indexed with a subscript "0").

$$RGDPMP = (1 + g^y)\ RGDPMP_{-1} \tag{9}$$

$$\frac{\sum_i \lambda_i^k K_i^d}{\sum_l \sum_i \lambda_{i,l}^l L_{i,l}^d} = \frac{\sum_i \lambda_{i,0}^k K_{i,0}^d}{\sum_l \sum_i \lambda_{i,l,0}^l L_{i,l,0}^d} = \chi^{kl} \tag{10}$$

Equation (11) and (12) determine the growth rates of labor and capital productivity for the non-agricultural sectors (subscript *nag*). The growth rates have two components, a uniform factor applied in all sectors to all types of labor and capital, $\gamma^l$ and $\gamma^k$, and a sector- and factor-specific factor, $\chi^l$ and $\chi^k$. In defining a baseline, the growth rate of GDP is exogenous, as well as the capital to labor ratio. In this case, equation (9) is used to calibrate the $\gamma^l$ parameter and equation (10) calculates the common growth rate for capital productivity, $\gamma^k$. In policy simulations, $\gamma^l$ and $\gamma^k$ are given, and equation (9) defines the growth rate of GDP, whereas equation (10) estimates the capital output ratio.

$$\lambda_{nag,l}^l = (1 + \gamma^l + \chi_{nag,l}^l)\ \lambda_{nag,l,-1}^l \tag{11}$$

$$\lambda_{nag,kt}^k = (1 + \gamma^k + \chi_{nag,kt}^k)\lambda_{nag,kt,-1}^k \tag{12}$$

Productivity growth in agriculture is treated differently. As already mentioned, in the last decade, Brazilian agriculture recorded high productivity growth, and we impose exogenous growth rate for productivity in agriculture uniformly across all factors, as shown in the following equations. Equation (13) represents the increase in labor productivity in agricultural sectors not subject to the uniform productivity shift factor $\gamma^l$. Equations (14) through (16) update productivity of capital, land and the sector specific factor, respectively. With agricultural productivity assumed to be uniform across all factors of production, the growth parameters $\chi^l$, $\chi^k$, $\chi^t$, $\chi^\gamma$ will be the same for all agricultural sectors.

$$\lambda_{ag,l}^{l} = (1+\chi_{ag,l}^{l})\lambda_{ag,l,-1}^{l} \tag{13}$$

$$\lambda_{ag,kt}^{k} = (1+\chi_{ag,kt}^{k})\lambda_{ag,kt,-1}^{k} \tag{14}$$

$$\lambda_{ag,lt}^{t} = (1+\chi_{ag,lt}^{t})\lambda_{ag,lt,-1}^{t} \tag{15}$$

$$\lambda_{ag}^{\gamma} = (1+\chi_{ag}^{\gamma})\lambda_{ag,-1}^{\gamma} \tag{16}$$

Additional support for a sector specific treatment of productivity where agriculture shows total factor productivity (TFP) growth rates higher than those for manufacturing comes from a recent panel study on sectoral productivity growth in OECD and developing countries.[14] In this study, depending on the estimation method, the average growth rate for agricultural TFP in middle-income developing countries ranges from 1.78 to 2.91 (in % per year).

Other elements of simple dynamics include exogenous growth of labor supply, with skilled labor growing faster than unskilled labor, and investment driven capital accumulation.[15]

Equation (17) determines labor supply growth for the skilled workers (unskilled labor supplies are determined in equations (6) and (7)). It simply applies an exogenous assumption about the growth of labor supply, $g^{ls}$, to the labor supply shift parameter. Equation (18) updates population. Equations (19) and (20) are similar growth equations for land and the sector-specific resource, respectively.

$$\alpha_{l}^{ls} = (1+g_{l}^{ls})\,\alpha_{l,-1}^{ls} \tag{17}$$

$$Pop = (1+g^{Pop})\,Pop_{-1} \tag{18}$$

$$Land = (1+g^{t})\,Land_{-1} \tag{19}$$

$$\gamma_{i}^{nr} = (1+g_{i}^{nr})\,\gamma_{i,-1}^{nr} \tag{20}$$

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14 See Martin and Mitra (1999).

15 Note that public investment, in this version of the model, has no impact on production technology.

Capital accumulation is based on the level of investment of the previous period less depreciation. Equation (21) represents the motion equation for capital growth, where δ is the rate of depreciation and *KAP* is the capital stock.

$$KAP = (1-\delta)KAP_{-1} + XF_{ZIp,-1} \tag{21}$$

Other exogenous variables may require updating for the baseline. An obvious one is government expenditure. This is typically assumed to grow at the same rate as GDP:

$$\overline{XF}_{Gov} = \left(1+g^{y}\right)\overline{XF}_{Gov,-1} \tag{22}$$

Other variables that have been updated include the various transfer variables, foreign savings, exogenous world prices (i.e. the terms of trade), and fiscal policies.

## 3.2 The Micro Model

The micro model is connected to the macro model through changes in the following set of endogenous (in the CGE model) link variables: (a) changes in agricultural and non-agricultural labor income of unskilled labor (2 variables); (b) changes in labor income of skilled labor (1 variable); (c) changes in the sectoral (agriculture vs. non-agriculture) composition of the unskilled workforce (1 variable). In addition, mimicking human capital upgrading, unskilled and skilled labor supplies grow at different rates and this is accounted in the micro data through a reweighing procedure.

The microsimulation does not consist of a series of cross-sections through time, but rather of a single cross-section that reflects the cumulative changes in the aforementioned exogenous and endogenous variables between 2001 and 2015.

The core part of the micro model is represented by the inter-sectoral migration equations for the unskilled workers and by the earnings equations. The estimation of these equations is described in detail in the following subsection. These equations, together with the reweighing, are then used to micro-simulate the changes observed in the CGE link variables so that the micro data will be consistent through aggregation with the macro data. Subsection 3.2.3 explains how this is done in practice. Finally, some potential caveats of these methods and data problems are outlined.

### *3.2.1 Estimation*

The sectoral mover-stayer model is estimated for unskilled heads and non-heads separately. For both heads and non-heads, we observe whether an individual has moved from agriculture into a non-agricultural sector. Our sample hence consists of those individuals who are still in agriculture and those who have moved out of agriculture within the last year.

Estimating such a model is only possible because the PNAD contains a special section on employment histories. This section allows identifying those who move out of agriculture and, very important for our undertaking, the characteristics of the movers at the time of moving, eliminating thus a source of endogeneity often present in migration models. For all the movers *before* they moved out of agriculture we know, for example, which type of land right they had if they were self-employed. To our knowledge, this information has not yet been exploited.

The estimated model combines the idea of the mover-stayer model from the migration literature[16] with the approach to modeling occupational dynamics applied in typical income generation microsimulations.[17] In the latter approach, bi- or multinomial choice models are estimated on the entire population. In our case, this would imply comparing the characteristics of those in agriculture with those in non-agricultural sectors. Instead, the mover-stayer model compares the characteristics of only the movers with those of the stayers. This appears to be more appropriate in the current setting, as our goal is to simulate the transition from agriculture to non-agriculture.

Let *move* be a dichotomous variable that assumes a value of 1 if the individual has moved out of agriculture in the last year, and 0 if the individual has stayed in agriculture. As indicated by equation (23), an individual will move (*move* = 1) if the utility (*U*) associated to this choice is higher than the utility of staying in agriculture.[18] Otherwise, the individual will stay in agriculture (24).

$$move = 1 \text{ if } U(move{=}1) > 0 \tag{23}$$

$$move = 0 \text{ otherwise.} \tag{24}$$

As indicated by equations (25) and (26), the utility of moving depends on a set of explanatory variables X and a random error term $\varepsilon$. A linear relationship between utility and the explanatory variables is assumed. The subscripts *msh* and *msnh* refer to heads and

[16] See for example Nakosteen and Zimmer (1980).

[17] See for example Robilliard, Bourguignon, and Robinson (2001) and Bussolo and Lay (2003).

[18] The utility of staying in agriculture is assumed to be 0. This is typical identifying assumption of the logit.

non-heads, respectively. They also serve to remind us that the parameters and variable vectors are from the mover-stayer (*ms*) model:[19]

$$U(move=1)_{msh} = \alpha_{msh} + X_{msh}\beta_{msh} + \varepsilon_{msh} \tag{25}$$

$$U(move=1)_{msnh} = \alpha_{msnh} + X_{msnh}\beta_{msnh} + \varepsilon_{msnh} \tag{26}$$

where $X_{msh}$ includes an educational dummy for more than 10 years of schooling, age, a dummy that refers to own-consumption worker, an employment category – to our knowledge unique to the PNAD – that describes workers who are not self-employed, do not receive any monetary income, and work "for their own consumption"[20], two dummies that refer to the type of land right held by the self-employed in agriculture, one referring to a situation, in which the landowner agrees with the self-employed occupying the land and another to the self-employed owning the land, and a regional dummy for the northern region.

For the non-heads, $X_{msnh}$ is a vector including similar variables and some important additions. It consists of three educational dummies, experience (age-schooling-6), experience squared, a female dummy, a dummy for blacks, and the same employment category and land right dummies as before plus a dummy for non-remunerated family members or workers. To take into account the role of the family-network in the migration decision, the explanatory variables for the non-heads include a dummy for the household head being employed in a non-agricultural sector and another dummy for the head being a mover out of agriculture. The reference group for the employment-related dummies are the wage-employed.

As we cannot observe the latent utility *U*, the parameters of the mover-stayer model will be estimated by maximum likelihood logit techniques, i.e. we estimate the models described by equations (27) and (28), where F denotes the cumulative density function of the logistic distribution.

$$\Pr ob(move_{msh} = 1 \mid X_{msh})_{msh} = F(\alpha_{msh} + X_{msh}\beta_{msh} + \varepsilon_{msh}) \tag{27}$$

$$\Pr ob(move_{msnh} = 1 \mid X_{msnh})_{msnh} = F(\alpha_{msnh} + X_{msnh}\beta_{msnh} + \varepsilon_{msnh}) \tag{28}$$

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[19] We do not use a subscript for indicating individual observations in the exposition of the micromodel for illustrative purposes.

[20] See Notas Metodológicas PNAD 2001.

Mincer wage/profit equations for unskilled labor in agriculture (the subscript *uagr*) and non-agriculture (*unagr*), and for skilled labor (*s*) are estimated as follows:

$$\ln w_{uagr} = \alpha_{uagr} + X_{uagr}\beta_{uagr} + uw_{uagr} \tag{29}$$

$$\ln w_{unagr} = \alpha_{unagr} + X_{unagr}\beta_{unagr} + uw_{unagr} \tag{30}$$

$$\ln w_{S} = \alpha_{S} + X_{S}\beta_{S} + uw_{S} \tag{31}$$

where the explanatory variables in all three equations include years of education, experience, the corresponding squared terms, a female dummy and racial dummies. In addition, we include regional dummies that in equations (30) and (31) also differentiate between rural and urban areas. In order to capture the labor input of unskilled agricultural workers, equation (29) includes two key variables: a dummy for being self-employed and the number of non-remunerated family members. The wage/profit equations (29) to (31) are estimated using Ordinary Least Squares (OLS).[21]

### *3.2.2 Estimation results*

With few exceptions, the explanatory variables of the mover-stayer models and the wage/profit equations are significant at the 5 percent level.[22] The detailed regression results are reported in the Appendices 7.1 and 7.2; here we just comment on some results that we find remarkable and consider of particular importance with regard to the simulation exercise.

The mover-stayer models appear to have some predictive power for the decision to move out of agriculture, as indicated, for example, by the Pseudo $R^2$ of 0.07 for the heads' and 0.15 for the non-heads' mover-stayer model. It should be noted that measures of fit for logit models can only provide a rough indication of whether a model is adequate (Long and Freese 2001).

In the mover-stayer model for heads, one educational dummy for 10 or more years of schooling, turned out to have a significant positive influence on moving out of agriculture. Yet, we find a number of factors that negatively affect the choice of moving,

[21] A short note on the potential problem of the selectivity bias in estimating these equations is added in the annex.

[22] Standard errors are adjusted for clustering.

among which age is the most important one. As we would expect, older individuals are less likely to move out of agriculture. The effect of a discrete change in age of some years is particularly strong for younger individuals. Working only for own-consumption also has quite a strong negative effect on the propensity to move out of agriculture. Many of these own-consumption workers are employed in the livestock sector and possibly even own livestock. In addition, if household heads own land or if they have an agreement with the landowner to occupy the land, they are more likely to stay in agriculture. Owning land or other agricultural production factors, such as livestock, hence acts as important barrier to intersectoral movements. Finally, household heads from the north are more likely to move out of agriculture, an interesting finding one might not necessarily expect, as the north is a region with a low share in agricultural employment.

As described above, the list of explanatory variables for non-heads is longer. The strongest determinant of moving out of agriculture is the dummy indicating whether the household head is employed in a non-agricultural sector. We can think of either a self-employed head being able to offer employment to other household members in a non-agricultural household enterprise or networks of a wage-employed head that facilitate finding non-agricultural employment for relatives. In addition, the choice of the household head to leave agriculture strongly influences the choice of the non-heads. Educational dummies for having finished primary and secondary education have a significant positive effect on the probability of moving out of agriculture. This effect is strongest for having finished primary education and declines somewhat for higher educational levels. The effect of a change in experience is much stronger than the effect of the corresponding change in the squared term. As in the case of the heads, the overall marginal effect of experience (including the squared term) declines with increasing experience. The subset of coefficients for educational dummies, experience, and squared experience can be interpreted as reflecting the earnings opportunities of an individual in non-agricultural employment. In other words, these five explanatory variables can be thought of as a reduced form representation of the wage differential between agricultural and non-agricultural activities. Accordingly, the coefficients for education can be seen to reflect decreasing returns to education for the movers and the results for experience appear to capture both the effect of age being a barrier to move out of agriculture as well as the typical seniority effect in earnings, i.e. increasing but marginally decreasing returns to experience. In a similar way, the significant and negative coefficients for racial dummies can be interpreted either or both as a direct barrier to non-agricultural employment and/or an argument in a reduced form wage differential model.

Non-remunerated workers are less likely to move out of agriculture. This finding point towards the importance of externalities associated to this type of employment, as estimation results indicate that the income gains due to an additional household member engaged in the household farm are rather moderate (see Appendix 7.2). The coefficients of being an own-consumption worker or owning land are of the same sign as in the case of the heads and the changes in predicted probabilities due to a change in the dummy of equal magnitude.

In sum, results for the heads emphasize the role of the barriers to moving out of agriculture, whereas, the possible gains of such a move are more strongly underlined by the estimation of the choice model for the non-heads. Household heads appear to respond to intersectoral wage differentials to a lesser degree, thus showing a tendency to be "trapped" in agricultural activities, possibly due to factor market imperfections. Their decision to stay or move however is of great importance for the choice of other household members.

### 3.2.3 Simulation

The microsimulation involves three steps. First, households are reweighted in order to reflect the change in the skilled/unskilled labor ratio that results from different growth rates of these two types of labor over time. In a second step, unskilled labor moves out of agriculture until the new share of unskilled labor in agriculture given by the CGE is reproduced. Third, wages/profits are adjusted according to the CGE results taking into account the changes in the skill composition of the workforce as well as the sectoral movements of unskilled labor from agriculture into non-agricultural sectors.

The reweighting procedure basically increases the weight of skilled individuals and decreases the weight of unskilled individuals to reach a new given ratio of unskilled to skilled workers following an efficient information processing rule.[23] Let *weight* denote the old weight (normalized to 1), and *nweight* the new weight of individual *i*. As Robilliard and Robinson (2001), we estimate the new weights by minimizing the Kullback-Leibler cross-entropy measure of the distance between the new and the old weights

$$\text{Min } \sum_i nweight_i \cdot \ln\left(\frac{nweight_i}{weight_i}\right) \tag{32}$$

subject to the following constraints

$$\frac{\sum_i nweight_i \cdot u_i}{\sum_i nweight_i \cdot s_i} = \frac{lu \cdot (1+g_u)}{ls \cdot (1+g_s)} = \frac{lu^*}{ls^*} \tag{33}$$

$$\sum_i nweight_i = 1 \tag{34}$$

with $u$ ($s$), a dummy variable for unskilled (skilled) individuals $i$, $lu$ ($ls$), the initial unskilled (skilled) labor force, and $g_u$ ($g_s$), the cumulative growth rate (between 2001 and 2015) of the unskilled (skilled) labor force. $lu^*$ ($ls^*$) hence denotes the target value for the number of unskilled (skilled) labor. Equation (33) hence states that the new weights have to reflect the new skill composition (the ratio of unskilled to skilled workers) of the workforce. Equation (34) is the adding-up normalization constraint.

Note that this procedure gives new individual weights for just the employed population. Yet, for our purposes we need household weights for entire population. So we averaged over the new weights in those households where one or more individuals were employed. Households without any employed members were assigned the old weight. Note that the resulting unskilled-skilled ratio under these "final" new weights is of course not exactly equal to the ratio imposed in the cross-entropy reweighting.[24] Since the workforce in agriculture is almost entirely unskilled (more than 95 percent), the share of the unskilled labor force in agriculture is only slightly lower under the new weights. We use these new weights throughout the following parts of the microsimulation.

The estimation of the sectoral choice logit model and the two wage equations provide the basis for the following steps in the simulation. In the second step, we apply the changes in the sectoral composition of the workforce from the CGE (from agricultural into non-agricultural sectors) to the microlevel. In the simulation, those individuals from agriculture with the highest propensity to move to non-agricultural sectors are chosen to

[23] For details on maximum entropy econometrics see Golan, Judge and Miller (1996). Robilliard and Robinson (2001) apply these methods to reweight household survey weights. They also provide a GAMS code for solving this type of problems.

[24] We acknowledge that this is an ad-hoc procedure. In principle, it is possible to reweight all individuals respecting all necessary constraints. Yet, we consider the value added of this computationally quite expensive exercise too low.

leave agriculture. This propensity is simulated by calculating the linear prediction of the logit model and adding a simulated residual.

Equations (35) to (39) indicate how we move unskilled individuals out of agriculture. Let the index j refer to all unskilled individuals employed in the agricultural sector and i to all employed individuals. Note that the share of unskilled agricultural employment may change (and actually does, but only slightly) because of the introduction of the new weights at this stage and that move* is 0 for all j, as their observed choice is to stay in agriculture. Individuals move to non-agricultural sectors, i.e. move* equals 1, if the utility associated to the choice to move increases. Equations (38) and (39) illustrate that we increase the utility of moving by augmenting the constants $\hat{\alpha}_{msh}$ and $\hat{\alpha}_{msnh}$ by $\Delta\alpha_{msh}$ and $\Delta\alpha_{msnh}$, respectively, in order to make individuals move.[25] Changes in the choices of the heads have an impact on the choices of the non-heads, as the head's choice enters the utility of the non-heads, indicated by $X^{*}_{msnh}$. The residuals $\hat{\varepsilon}^{1}_{msh}$ and $\hat{\varepsilon}^{1}_{msnh}$ are simulated such that the resulting utility is consistent with the observed outcome in the initial situation.[26] Using a Newton-Raphson algorithm, we augment the constants until equation (35) holds.

$$agr\tilde{s}hare = \frac{\sum_j nweight_j - \sum_j move^{*}_j \cdot nweight_j}{\sum_i nweight_i} \tag{35}$$

with

$$move^{*} = 1 \text{ if } U^{*}\,(move^{*}=1) > U^{*}\,(move^{*}=0) \tag{36}$$

$$move^{*} = 0 \text{ otherwise} \tag{37}$$

and

$$U^{*}(move^{*}=1)_{msh} = \left(\hat{\alpha}_{msh} + \Delta\alpha_{msh}\right) + X_{msh}\hat{\beta}_{msh} + \hat{\varepsilon}^{1}_{msh} \tag{38}$$

[25] Choosing to change the intercept means that we change the propensity to migrate of everybody irrespective of their personal characteristics. This 'neutrality' may not be correct but it is the simplest assumption lacking additional information.

[26] There are also residuals associated to *move* = 0, which is why the residuals of *move* =1 have the superscript 1.

$$U^*(move^* = 1)_{msnh} = \left(\hat{\alpha}_{msnh} + \Delta\alpha_{msnh}\right) + X^*_{msnh}\hat{\beta}_{msnh} + \hat{\varepsilon}^1_{msnh} \tag{39}$$

In order to determine both $\Delta\alpha_{msh}$ and $\Delta\alpha_{msnh}$ we need another equation. We decided to fix the share of heads and non-heads movers so that equation (40) holds.

$$\frac{\sum_j move_j^{msh} \cdot weight_j}{\sum_j move_j^{msnh} \cdot weight_j} = \frac{\sum_j move^{*\,msh}_j \cdot nweight_j}{\sum_j move^{*\,msnh}_j \cdot nweight_j} \tag{40}$$

Equation (40) implies that the ratio of head to non head movers is constant and equal to the value observed in the base year. Previous studies micro-simulating similar individual choices used the simple rule of imposing equal 'deltas' for both the heads and non-heads. In our Brazilian case this would imply that the ratio of heads to non-heads movers would change dramatically from the observed historical value and decided to opt for the different constraint represented by equation (40).

After the assigning new weights and moving individuals out of agriculture, wages/profits need to be adjusted according to the CGE results in the third step of the simulation. We illustrate the procedure of adjusting the constants of the wage/profit equations for unskilled labor only.[27] Let *k=1,…,K* be an index for unskilled individuals still employed in agriculture (excluding non-remunerated household members), *k=K+1,…,M* for the movers, and, finally, *k=M+1,…,L* for those unskilled in non-agricultural sectors who have been employed there before (again excluding non-remunerated household members). We assume that non-remunerated household members earn an own labor income once they move out of agriculture. In equations (42) and (44) we calculate the target values for average labor income in agricultural and non-agricultural sectors, $\tilde{w}_{uagr}$ and $\tilde{w}_{unagr}$, respectively, simply by multiplying initial average labor income by the growth rates $g_{uagr}$ and $g_{unagr}$ given by the CGE. These target values for the new distribution are reached by adjusting the constants in the wage/profit equations, as indicated by equations (43) and (45), taking into account the new weights that reflect the changed skill composition of the labor force. Note that for agriculture the procedure is slightly more complicated, as we also have to take into account that the dummy for agricultural self-employment as well as the number of non-remunerated family members might change, indicated by $X^*_{uagr}$ in equation (43).

[27] For skilled labor, the adjustment in the constant only needs to account for the changes in weights.

$$\tilde{w}_{uagr} = \frac{\sum_{k=1}^{M} w_{uagr\,k} \cdot weight_k}{\sum_{k=1}^{M} weight_k} \cdot \left(1 + g_{uagr}\right) \tag{42}$$

$$\begin{aligned} \tilde{w}_{uagr} &= \frac{\sum_{k=1}^{K} w^{*}_{uagr\,k} \cdot nweight_k}{\sum_{k=1}^{K} nweight_k} \\ &= \frac{\sum_{k=1}^{K} \exp\left( (\alpha_{uagr} + \Delta\alpha_{uagr}) + X^{*}_{uagr} \hat{\beta}_{uagr} + \hat{uw}_{uagr} \right)_k \cdot nweight_k}{\sum_{k=1}^{K} nweight_k} \end{aligned} \tag{43}$$

$$\tilde{w}_{unagr} = \frac{\sum_{l=M+1}^{L} w_{unagr\,l} \cdot weight_l}{\sum_{l=M+1}^{L} weight_l} \cdot \left(1 + g_{unagr}\right) \tag{44}$$

$$\begin{aligned} \tilde{w}_{unagr} &= \frac{\sum_{l=K+1}^{L} w^{*}_{uagr\,l} \cdot nweight_l}{\sum_{l=K+1}^{L} nweight_l} \\ &= \frac{\sum_{l=K+1}^{L} \exp\left( (\alpha_{uagr} + \Delta\alpha_{uagr}) + X_{unagr} \hat{\beta}_{unagr} + \hat{uw}_{unagr} \right)_l \cdot nweight_l}{\sum_{l=K+1}^{L} nweight_l} \end{aligned} \tag{45}$$

The unexplained wage $\hat{uw}_{unagr}$ for those who enter non-agriculture is calculated by taking the unexplained wage from agriculture and multiplying it by the ratio of the standard deviations of the residuals in the non-agricultural and agricultural sectors, respectively. For non-remunerated household members moving into non-agricultural sectors we simulate a residual.

In addition to labor income, we consider transfer and capital income as reported in the PNAD. Transfer income is scaled up or down with the GDP per capita growth rate and capital income with the change in the rental rate from the CGE model. The sum of all household members’ individual incomes is divided by the number of household members to give the income per capita. We use regional poverty lines taking a R$ 80 per capita poverty line (in current 2001 prices) for urban Rio de Janeiro as a basis and adjusting for regional price differences following Paes de Barros (2004). The poverty lines are reported in appendix 7.4.

### 3.2.4 Shortcomings

The household income generation process is of course much more complex than the proposed micro-simulation model suggests. Many structural features of the Brazilian labor market, such as a high degree of informality in wage-employment and the important role of self-employment, are only accounted for rudimentarily. Additionally, the data used to estimate the mover-stayer model may capture long-term transitions from agricultural into non-agricultural employment, but also some temporary job shift, for example due to seasonality. Doubts have emerged regarding the reliability of the information drawn from the PNAD, in particular on rural, informal sector, and capital income (World Bank 2003).

Finally, it may seem natural to assume that the sectoral movements are somehow related to geographical migration from rural to urban areas, either within or even between the Brazilian regions.[28] Traditionally, migration has acted as an important adjustment mechanism in Brazil. Nearly 40 percent of all Brazilians have migrated at one point in their lives (Fiess and Verner 2003). However, the data does not allow to link intersectoral movements to geographical migration. First, migration-related questions of the PNAD do not cover rural-urban migration. The available information is on whether an individual has moved between municipalities and/or between federal states. Second, using the information on migration in combination with the employment history from the PNAD 2001 suggests that only a minor share, of about 12 percent of those leaving the agriculture, actually migrates to another municipality. Approximately half of these migrants move to another federal state. In light of the importance of migration as an adjustment mechanism and the fact that the decline in agricultural employment is accompanied by a reduction in the rural population of equal magnitude, we think that these figures reflect data deficiencies rather than the Brazilian reality. It is quite likely that migrants are underrepresented in the PNAD. Therefore, we had to ignore the issue of geographical migration here due to the low share of “geographical” migrants among the

[28] This would of course add to the list of arguments why the labor market for the unskilled should be considered segmented.

sectoral movers. Exploring these issues further and extending the model by linking structural change to geographical migration could prove a fruitful exercise, particularly in the Brazilian context.

# 4 Brazil in the Next Decade: How Trade Policy Affects a Business as Usual Scenario

A central question of this paper is assessing the poverty effects of trade policy reforms in the long run, when many structural adjustment forces shape the income generation process. Our starting point consists of using our CGE model to build a business as usual scenario depicting the evolution of the Brazilian economy in the next decade. This evolution should not be considered as a statistical forecast, but rather as a consistent "projection" of the economy in a future where inter-sectoral productivity growth differentials, skill upgrading, and migration of labor out of farming activities play major roles. This Business as Usual (BaU) projection is then contrasted with alternative scenarios where trade policy reforms are added. The following subsections, describe in details the macro and micro results for the BaU and trade scenarios.

## 4.1 The Business as Usual Macro Results

In the BaU scenario, real GDP for Brazil is projected to grow (from 2005 onwards) at the fairly sustained yearly rate of 3.3%; this is somewhat optimistic when compared with the recent two decades' (1980-2000) rate of 2%. This GDP growth performance is backed up by strong factor productivity growth rates. As explained above, productivity in the agriculture sector is factor neutral and its growth rate is exogenously set at 2.9% per year[29]; in the non-farm sectors, growth of labor productivity is calibrated at 1.02% per year and growth of capital productivity at 0.82% per year.

These differences in productivity growth rates across sectors, combined with faster growth of the supply of skilled versus unskilled labor generate significant structural adjustments, in line with those observed for the last decade. The changes in the structure of labor markets, shown in Table 2, are of particular relevance for poverty and income distribution trends. On the supply side, education increases the supply of skilled workers which is growing at a 2.0% annual rate versus a yearly 1.6% growth rate for the unskilled labor supply. Additionally, through out-migration, the supply of unskilled workers in

[29] Note that this value is at the high end of the estimations of TFP growth rates by Martin and Mitra (1999), see page 15.

agriculture is shrinking. Labor demand is affected by the following three factors: labor productivity in agriculture is exogenous and slightly higher than in the rest of the economy; income elasticity of private consumption is below one for agricultural commodities and above one for other commodities; and, finally, international prices for traded agricultural products are decreasing through time. These three factors concur in reducing demand for labor in agricultural sectors and are the key drivers for the migration towards the non-agricultural segment.

These trends in the supply and demand for labor are equilibrated by movements in relative wages. In the time horizon considered here, real wages of the skilled increase at 1.3% annually. In non-agricultural sectors, wages for unskilled workers increase by the yearly rate of 0.9%, however their upward trend is dumped by migration. Conversely, the implied reduction of supply due to out-migration boosts agricultural wages which are growing at a 1.7% annual rate.

*Table 2: Medium term labor market structural adjustments, 2001-2015*

| | Producti-vity of L | Income Elast of Demand | Employment | | Wages | | Unskilled Lab Migration as % of: | | Cumulative Migration |
|---|---|---|---|---|---|---|---|---|---|
| | | | Skilled | Unskilled | Skilled | Unskilled | Sending Pop | Receiv-ing Pop | 2001-2015 |
| | Yearly gr | constant | Yearly growth rates | | | | Yearly % | | Millions |
| Agri | 2.9 | 0.54 | | 0.0 | | 1.7 | 1.7 | | -4.0 |
| Non-Agri | 1.0 | 1.05 | | 2.2 | | 0.9 | | 0.5 | 4.0 |
| Economywide | | | 2.0 | 1.7 | 1.3 | | | | |

Source: Authors' calculations

As shown in Table 3 these structural trends result in a significant 5 percent points shrinking in the agricultural employment for unskilled combined with a reduction of the unskilled wage gap between agriculture and non-agriculture. Notice that the employment percent structure of this table is one of the key variables linking the macro and micro models.

*Table 3: Employment shares and wage ratios in 2001 and 2015*

| | Employment % | | | | Unskilled Wages | |
|---|---|---|---|---|---|---|
| | 2001 | 2015 | 2001 | 2015 | 2001 | 2015 |
| | Skilled | | Unskilled | | | |
| Agri | 4 | 3 | 27 | 22 | | |
| Non-Agri | 96 | 97 | 73 | 78 | | |
| Ratio N-Agri/Agri | | | | | 1.8 | 1.6 |

Source: Authors' calculations

These 2001-2015 structural trends should not be taken as forecasts of what is going to happen to the Brazilian economy; these are just assumed and correspond broadly to what has happened to Brazil in the last decade. They serve as a benchmark against which alternative scenarios are compared. These across scenarios comparisons are the real value added of the modeling exercise rather than the levels the variables are estimated to be in a particular future year.

The BaU's GDP and labor markets macro trends are linked to developments at the sectoral level (shown in Table 4). Output growth rates are slightly lower for the agricultural sectors than for the non-agricultural ones. Agriculture exports, due to falling primary commodity international prices, grow at a slightly lower pace than non-agriculture exports. Additionally, in agricultural sectors, employment of unskilled workers is stalled or reduced, whereas demand for skilled workers, whose wages are increasing at a contained pace, is increasing. Productivity gains dictate that less workers are needed to achieve the same output, and rising wages, in particular for unskilled workers, induce producers to substitute (although with a low level of substitution) skilled workers for unskilled ones. The rightmost panel of the table shows the relative sizes of sectors in terms of employment and the skill intensities of each sector. Services are the largest employers of both skilled and unskilled workers but, on average, they use skilled labor more intensively. Agriculture employs almost a third of unskilled workers and uses this factor quite intensively, whereas manufacturing labor intensities are in-between agriculture and services.

*Table 4: BaU's output and trade sectoral growth rates, and employment intensities*

| | Annual average growth rates | | | | | Employment percentages | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Labor Demand | | by sector | | by skill | |
| | Output | Imports | Exports | Skilled | Unsk. | Skilled | Unsk. | Skilled | Unsk. |
| CerealGrains | 3.2 | 2.5 | 2.3 | 0.3 | 0.1 | 0 | 5 | 2 | 98 |
| OilSeeds | 3.1 | 2.2 | 2.4 | 0.1 | -0.1 | 0 | 1 | 6 | 94 |
| RawSugar | 3.2 | | | 0.2 | 0.1 | 0 | 1 | 4 | 96 |
| OtherCrops | 2.9 | 1.3 | 2.5 | 0.0 | -0.1 | 1 | 12 | 3 | 97 |
| Livestock | 3.2 | 1.5 | | 0.3 | 0.1 | 2 | 4 | 10 | 90 |
| RawAnimalProducts | 3.3 | 2.5 | 1.6 | 0.4 | 0.3 | 0 | 3 | 1 | 99 |
| OilMinerals | 3.3 | 3.0 | 2.9 | 1.5 | 1.7 | 0 | 0 | 15 | 85 |
| LightManufacturing | 3.3 | 0.8 | 3.7 | 1.0 | 1.2 | 1 | 2 | 16 | 84 |
| AgriIndustriesExp | 3.2 | 0.5 | 3.4 | 1.0 | 1.2 | 2 | 3 | 16 | 84 |
| WoodProductsPaper | 3.3 | 0.9 | 3.5 | 1.0 | 1.2 | 2 | 2 | 15 | 85 |
| ChemicalsOilPr | 3.3 | 1.8 | 2.9 | 1.1 | 1.3 | 2 | 1 | 30 | 70 |
| MetalMineralProducts | 3.5 | 1.8 | 3.3 | 1.2 | 1.4 | 2 | 2 | 17 | 83 |
| MachineryEquipment | 3.6 | 1.9 | 3.5 | 1.4 | 1.6 | 3 | 2 | 28 | 72 |
| OtherServices | 3.0 | 2.6 | 1.7 | 2.1 | 2.3 | 58 | 30 | 33 | 67 |
| Construction | 3.2 | | | 2.3 | 2.5 | 2 | 8 | 6 | 94 |
| TradeCommunication | 3.1 | 2.4 | 1.8 | 2.2 | 2.4 | 15 | 18 | 17 | 83 |
| PublicServices | 3.1 | 2.7 | 1.7 | 2.2 | 2.4 | 9 | 4 | 41 | 59 |
| Agri | 3.0 | 1.9 | 2.4 | | 0.0 | 4 | 27 | 6 | 96 |
| Non-Agri | 3.2 | 2.0 | 3.1 | | 2.2 | 96 | 73 | 29 | 76 |
| Economywide | 3.2 | 2.0 | 3.1 | 2.0 | | 100 | 100 | 28 | 76 |

Source: Authors' calculations. Note: the mapping of this table sectors and GTAP sectors is shown in appendix 7.5, see Table 24 and Table 25.

## 4.2 Distributional and Poverty Results for the BaU

A moderate decrease in poverty between 2001 and 2015 results from micro-simulating the identified key structural trends on the Brazilian household data. Considering the full sample of all households, the headcount poverty ratio (P0) declines by about 6 percentage points (see Table 5). The reduction of the average normalized poverty gap (P1) and the poverty severity index (P2) indicates that those who remain poor move closer to the poverty line.[30] Inequality changes very little, as indicated by the 0.1 decrease in Gini coefficient (or as in the Theil or other inequality indices, not reported).

These average indices indicate that some progress in reducing aggregate poverty and inequality is achieved in a Business as Usual scenario, but these aggregate measures may conceal relevant distributional changes at a more disaggregated level. In fact, reaching stronger poverty reduction may require specific pro-poor policies which often rely, for their successful implementation, on more detailed information about disaggregated distributional effects.

A first obvious way to gather more detailed information is to analyze the poverty and inequality impacts separately for the agricultural and non-agricultural households.

*Table 5: Poverty and inequality in the BaU scenario, by sectors*

| | All households | | Non-agricultural households | | Agricultural households | |
|---|---|---|---|---|---|---|
| | 2001 level | 2001-15 change | 2001 level | 2001-15 change | 2001 level | 2001-15 change |
| PC income | 314.9 | 1.5 | 351.9 | 1.2 | 148.3 | 2.3 |
| Gini | 58.6 | -0.1 | 57.1 | 0.6 | 56.6 | -0.7 |
| P0 | 23.6 | -5.6 | 18.6 | -3.1 | 46.2 | -13.8 |
| P1 | 9.6 | -3.0 | 7.1 | -1.6 | 21.0 | -8.0 |
| P2 | 5.3 | -1.8 | 3.7 | -0.9 | 12.3 | -5.2 |
| Population % | 100 | | 81.8 | 3.3 | 18.2 | -3.3 |
| Contr. to P0 | | | 64.4 | 8.8 | 35.6 | -8.8 |

Source: Authors' calculations. Note: PC income is per capita income in 2001 R$ and the change is given as annual growth rate. All levels are in percent and changes in percentage points.

A household is classified as "agricultural" when its head or at least two of its members are employed in agriculture. In 2001, according to this classification, agricultural

[30] A short note on the interpretation of the reported poverty measures: The income-gap ratio, i.e. average income shortfall (of the poor) divided by the poverty line, can be calculated as P1/P0. This ratio is 0.4 for all households in our case, i.e. the perfectly targeted cash transfer needed to lift every poor person out of poverty is 40 percent of the poverty line times the number of the poor. Thus, 0.4 times the percentage point change in P0 (here 2.4) provides a percentage point change benchmark for evaluating the change in P1, as this would be the change in P1 that we would observe had the average income of the poor stayed constant while the headcount declined.

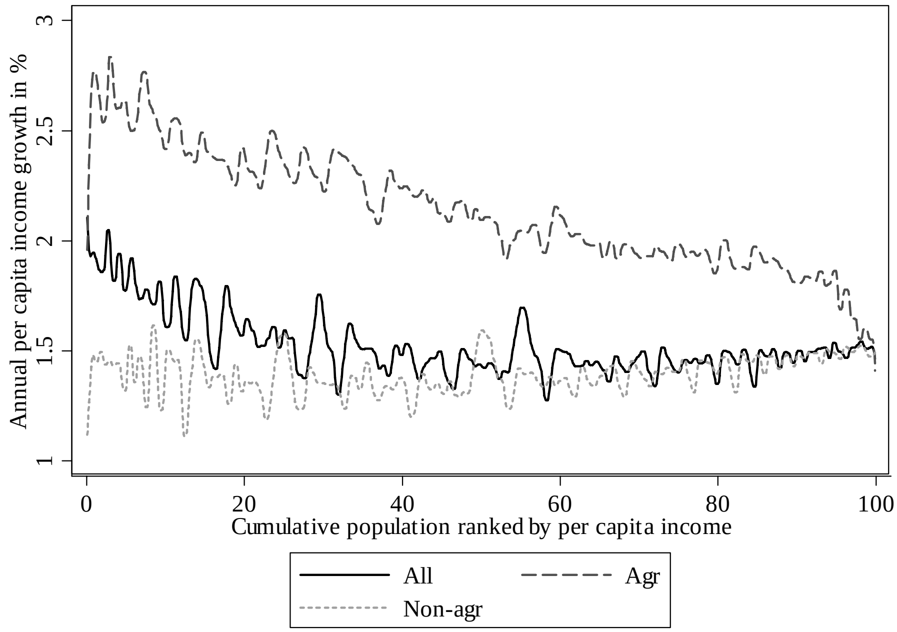
households accounted for 18.2 percent of the Brazilian population, poverty incidence among them almost reached 50 percent, and their contribution to total poverty was about 36 percent (see Table 5). Between 2001 and 2015, the share of agricultural households in the population shrinks by 3.3 percentage points following the decline in agricultural employment of more than 5 percentage points. Poverty among agricultural households falls by more than 13 percentage points, whereas poverty among non-agricultural households decreases by only 3.1 percent. Accordingly, the contribution of agricultural households to the headcount falls by almost 9 percentage points.

A more detailed analysis also shows that the lack of progress in aggregate inequality is due to the agricultural and non-agricultural groups' individual inequality indicators moving in opposite directions. Among non-agricultural households, inequality rises because skilled labor income, a major source of income for these households, grows faster than that of unskilled labor. Conversely, inequality among agricultural households falls, mainly because richer agricultural households earn a higher share of their income from non-agricultural unskilled labor and, in some cases, from skilled labor.

Another way of analyzing detailed distributional effects is to consider growth incidence curves. These curves plot per capita income growth at income percentiles (Ravallion and Chen 2003) and are shown in Figure 1 for all households as well as for the agricultural and non-agricultural groups.[31] Reflecting the increase in unskilled agricultural wages from the CGE model's results, per capita income growth is much higher for agricultural households. In addition, the agricultural growth incidence curve illustrates a strong pro-poor distributional shift, which reflects both the increase in agricultural labor incomes and the gains resulting from moving out of agriculture.

[31] The household category, i.e. agricultural or non-agricultural household, is the category the household belonged to in the base year 2001.

*Figure 1: Growth incidence curves, BaU, all, agricultural, and non-agricultural households*




Source: Authors' calculations.

These agricultural households specific distribution shifts also explain the pro-poor changes in the national distribution, since only minor distributional changes are registered in the non-agricultural distribution. However, richer non-agricultural households experience somewhat higher gains than poorer households. Non-agricultural poor household incomes increase by a meager 1 to 1.5 percent annually.

These more detailed analyses of the long term evolution of the Brazilian income distribution highlight the different roles played by changes in inequality and shifts in the growth rates of the average incomes. The following two questions then arise: if the current (2001) distribution of income were to remain unchanged, to what extent would the additional growth under the BaU scenario contribute to reducing poverty? And what is the poverty reducing role of the BaU differential in growth rates for the agriculture and non-agriculture segments?

Answering these questions requires performing two additional micro-simulations as follows. The first simulation generates a counterfactual distribution under the assumption that all incomes out of all sources grow by 1.5 percent annually. This implies shifting the entire income distribution "to the right" leaving its shape unchanged. Individuals do not change employment sectors and hence households retain their initial non-agricultural or agricultural classification. Results are presented in Table 6 and changes are given as percentage share of the BaU change (column I). In addition, we simulated a second counterfactual distribution for agricultural and non-agricultural households separately with per capita incomes of the respective household types growing with the BaU rates, i.e. by 1.3 percent annually for non-agricultural and 2.4 percent annually for the agricultural households (column II).

*Table 6: Poverty and inequality in a distributionally neutral scenario*

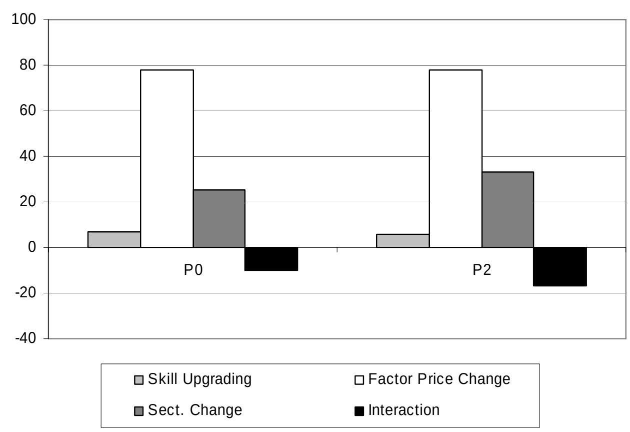
| | All households | | | Non-agricultural households | | | Agricultural households | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2001 level | % of BaU change I | % of BaU change II | 2001 level | % of BaU change I | % of BaU change II | 2001 level | % of BaU change I | % of BaU change II |
| PC income | 314.9 | 100.0 | 100.0 | 351.9 | 117.7 | 98.6 | 148.3 | 65.7 | 102.9 |
| P0 | 23.6 | 91.7 | 102.4 | 18.6 | 139.8 | 133.3 | 45.9 | 56.5 | 90.5 |
| P1 | 9.6 | 90.9 | 97.7 | 7.1 | 132.5 | 119.7 | 20.8 | 61.9 | 93.2 |
| P2 | 5.3 | 86.8 | 97.9 | 3.7 | 125.6 | 114.3 | 12.1 | 62.6 | 93.4 |

Source: Authors' calculations.

The comparison of the counterfactual simulations of the "completely" distributionally neutral (column I) and the "separately" neutral (column II) scenarios shows that the growth bias in favor of agricultural households is poverty reducing. Yet, the difference between the BaU and the completely neutral scenario does not seem too pronounced. This is due to the fact that poverty among non-agricultural households is reduced much more than in the BaU, where the income distribution among these households worsens. This "slight" worsening of the income distribution hence hampers quite strongly the potential of growth to reduce poverty among non-agricultural households. In addition, the differences between the two neutral scenarios for non-agricultural households illustrate that a 0.2 percentage point difference in annual growth rates for 14 years can make a difference in terms of poverty reduction. The last two columns of Table 6 show the importance of growth for reducing poverty among agricultural households as well. A 0.9 point percentage point difference in annual income growth rates for 14 years implies a reduction of about 5 percentage points less in the headcount over this time period. In contrast to what we see for non-agricultural households, the impact of the pro-poor distributional shift for agricultural households observed in the BaU is relatively small. In other words, had the income distribution among agricultural households not improved, growth would have reduced poverty by only little less.

The poverty reductions recorded in the BaU scenario are due the change in skill endowments, the increase in real factor prices, and inter-sectoral movements. A main advantage of micro-simulation techniques is their ability to decompose the total effect in different partial effects that can be attributed to single causes. A slight complication arises because different causes interact. The interaction arises because factor incomes increase at different rates in agricultural and non-agricultural sectors. By simulating counterfactual distributions, where only one cause at the time, or a combination of two of them, are included, it is possible to decompose the total effect into individual or joint (interactive) contributions.

*Figure 2: Decomposition of poverty changes, BaU, all households*




Source: Authors' calculations. Note: The figure displays the contribution of the respective component to the total change in P0 and P2, respectively, in percent. The contributions add to 100. Contributions refer to reductions in the respective poverty indices.

Figure 2 displays the results of this decomposition. Factor price changes account for the largest share of total poverty reduction. The change in the skill composition of the workforce does not contribute much to poverty reduction, whereas the sectoral shifts are quite important, in particular for the poorer among the poor, as the higher contribution of the sectoral change component with regard to P2 indicates. This implies that households with members moving out of the agricultural sector escape poverty. We consider this issue in more detail later. The interaction component, which actually is a sum of distinct interaction components, hampers poverty reduction. Counterfactual simulations show that the interaction between sectoral movements and income changes is the most important one. It is negative since people move out of agriculture where their incomes would have increased much more than in non-agricultural sectors.

In sum, the distributional and poverty analysis suggests that the BaU scenario leads to relatively little poverty reduction. Agricultural households fare quite well and the poverty incidence and intensity among them is reduced quite substantially. Decomposition analyses show that sectoral change contributes quite significantly to poverty reduction, although income growth is the most important source of poverty reduction. Micro-accounting exercises underline the importance of growth for poverty reduction, but we also illustrate that slight increases in inequality can considerably reduce the poverty reduction potential of growth in the context of a high-inequality country, such as Brazil.

## 4.3 Macro results for the full liberalization and the Doha trade policy shocks

The trade shocks simulated in the dynamic CGE model consist of changes in Brazilian tariff protection against imports from the rest of the world and of exogenous changes of international prices of traded goods and export quantities demanded by foreigners.[32] The shocks are assumed to take place progressively through a gradual phasing-in starting in 2005 and lasting 6 years. Table 7 displays these shocks as percentage changes of the final year (2015) between the BaU and the trade reform scenarios. As part of the shock and to leave the government fiscal balance unchanged, tariff revenue losses are compensated by a lump sum transfer implemented as an increase in the direct taxes paid by households. This lump sum additional tax is the least distortionary instrument that can be readily used in our model, however, in practice, the Brazilian government may chose other forms of compensatory taxes which may alter relative prices and have significant income distribution effects.

[32] It should be noted that to mimic the global model results for increased demand for Brazilian exports and changes in international prices, we introduce a downward sloping export demand function as shown in equation (1) above. During a shock, for obvious reasons, we cannot target both prices and quantities and the shock is implemented by modifying both the international price index *WPEindex* (the price shock) and the intercept $\alpha^e_k$ (the quantity shock). Our Brazil (single-country) model will then endogenously determine the quantity supplied.

*Table 7: Trade shock – Tariff reductions and international prices changes*

| | Own Tariff reductions | | | Change in import prices | | | Change in export prices | | |
|---|---|---|---|---|---|---|---|---|---|
| | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha |
| CerealGrains | -100 | | | 8 | 2.0 | 2.1 | 16 | 5.9 | 6.0 |
| OilSeeds | -100 | | | 6 | 2.5 | 2.5 | 14 | 4.8 | 4.9 |
| RawSugar | | | | 2 | 0.9 | 1.0 | 14 | 5.3 | 5.4 |
| OtherCrops | -100 | 0 | 0 | 2 | 0.9 | 0.9 | 13 | 4.7 | 4.8 |
| Livestock | -100 | | | 2 | 1.0 | 1.1 | 25 | 9.7 | 9.8 |
| RawAnimalProducts | -100 | | | 2 | 0.4 | 0.4 | 18 | 6.6 | 6.7 |
| OilMinerals | -100 | 0 | | 0 | 0.1 | 0.1 | 2 | 1.1 | 1.3 |
| LightManufacturing | -100 | -6 | 0 | 1 | 1.1 | 1.2 | 9 | 3.8 | 4.0 |
| AgriIndustriesExp | -100 | -4 | -1 | 0 | 0.6 | 0.6 | 7 | 3.0 | 3.2 |
| WoodProductsPaper | -100 | -6 | -2 | 0 | 0.0 | 0.0 | 4 | 1.8 | 2.0 |
| ChemicalsOilPr | -100 | -11 | -3 | -1 | -0.1 | 0.0 | 3 | 1.4 | 1.7 |
| MetalMineralProducts | -100 | -6 | -1 | 0 | 0.0 | 0.0 | 3 | 1.6 | 1.7 |
| MachineryEquipment | -100 | -7 | -2 | 0 | 0.0 | 0.0 | 2 | 1.5 | 1.7 |
| OtherServices | | | | 0 | 0.0 | 0.0 | 5 | 2.0 | 2.2 |
| Construction | | | | 0 | 0.0 | 0.0 | 4 | 1.7 | 1.9 |
| TradeCommunication | | | | 0 | -0.1 | -0.1 | 5 | 1.9 | 2.1 |
| PublicServices | | | | 0 | -0.1 | -0.1 | 5 | 2.1 | 2.3 |
| Agri | -100 | 0 | 0 | 5 | 1.5 | 1.5 | 14 | 4.8 | 4.9 |
| Non-Agri | -100 | -7 | -2 | 0 | 0.0 | 0.1 | 4 | 1.9 | 2.1 |
| Economywide | -100 | -7 | -2 | 0 | 0.1 | 0.1 | 5 | 2.2 | 2.4 |

Source: Authors' calculations.

The full liberalization scenario has the largest impacts: tariffs are completely eliminated and Brazil enjoys strong terms of trade gains; the other two shocks, representing two possible versions of the Doha negotiation outcomes, generate almost no own liberalization and fairly muted global prices effects. In order to fully appreciate their final effects, these shocks need to be mapped to the economic structure of Brazil. Table 8 presents this structure and helps in this regard. For instance, in the full liberalization scenario, export oriented sectors – those displaying high shares of export to domestic output – such as Oilseeds, Other Crops and the industrial sectors transforming agricultural products (*AgriIndustriesExp* which buys most of its inputs from agriculture) record considerable increases of their export prices. Conversely, import competing sectors, such as Chemicals and Oil derived products and capital goods, do not face high increases in their international prices. These combined export and import price movements result in fairly strong terms of trade gains, inducing significant reallocation of resources towards export oriented sectors. Additional push for this reallocation comes from Brazil's own liberalization which entails a reduction of the anti-export bias implicit in the higher protection rates for manufacturing of the initial tariff structure.

*Table 8: Initial (year 2001) structure of the Brazilian economy*

| | tariff rates | Sectoral Imports | Imports / DomDemand of Composite | Sectoral Output | Sectoral Exports | Exports / Dom Output |
|---|---|---|---|---|---|---|
| CerealGrains | 7 | 1 | 15 | 1 | 0 | 1 |
| OilSeeds | 6 | 0 | 8 | 0 | 4 | 29 |
| RawSugar | 0 | 0 | 0 | 0 | 0 | 0 |
| OtherCrops | 9 | 2 | 3 | 4 | 8 | 7 |
| Livestock | 3 | 0 | 1 | 1 | 0 | 0 |
| RawAnimalProducts | 8 | 0 | 1 | 1 | 0 | 1 |
| OilMinerals | 4 | 7 | 33 | 1 | 7 | 25 |
| LightManufacturing | 17 | 4 | 5 | 5 | 3 | 2 |
| AgriIndustriesExp | 18 | 3 | 3 | 7 | 19 | 11 |
| WoodProductsPaper | 9 | 2 | 5 | 3 | 7 | 10 |
| ChemicalsOilPr | 9 | 15 | 10 | 9 | 8 | 3 |
| MetalMineralProducts | 12 | 5 | 6 | 5 | 13 | 11 |
| MachineryEquipment | 19 | 37 | 27 | 8 | 20 | 11 |
| OtherServices | 0 | 11 | 3 | 23 | 5 | 1 |
| Construction | 0 | 0 | 0 | 8 | 0 | 0 |
| TradeCommunication | 0 | 10 | 5 | 13 | 5 | 2 |
| PublicServices | 0 | 2 | 1 | 11 | 1 | 0 |
| Agri | 8 | 4 | 4 | 7 | 12 | 6 |
| Nagri | 11 | 96 | 6 | 93 | 88 | 4 |
| Economywide | 11 | 100 | 6 | 100 | 100 | 4 |

Source: Authors' calculations.

These effects are detailed in Table 9. The complete elimination of tariffs in the full liberalization case explains the large increase of imports (measured in volume) which, in the final year of this scenario, is 21% above the value in the same year of the BaU. Increases in imports of agricultural goods are much weaker: an aggregate 6% increase versus the 21% surge of the non-agriculture bundle. The combination of lower initial tariffs and stronger international price increases for agriculture, with respect to non-agriculture, explain the difference in import response of these two aggregate sectors. Given their very limited scope of tariff reduction, the Doha scenarios imply much more contained changes of imports.

With high elasticity of substitution in demand, cheaper imports have the potential to displace domestic production, especially for those goods whose demand is fulfilled by a large share of foreign supply. For Brazil, this is the case for the Chemicals, and Capital goods sectors. In the full liberalization scenario, domestic production experiences significant market share losses in these sectors; however this is not happening in the Doha cases. The competition from cheaper imports is also reflected – again only for the full liberalization case – in the decline of prices of domestic output.

*Table 9: Brazil' structural adjustment, per cent changes in the final year between BaU and trade shocks*

| | Demand side | | | | | | | | | Supply side | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Import Volumes | | | Domestic Demand of dom products | | | Price of domestic output in dom mkts | | | Export Volumes | | | Domestic Output | | | Price of domestic output | | |
| | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha |
| CerealGrains | -6 | -3 | -3 | 4 | 1 | 1 | -2 | 1 | 1 | 68 | 14 | 13 | 5 | 1 | 1 | -2 | 1 | 1 |
| OilSeeds | -18 | -8 | -7 | 5 | 1 | 1 | -6 | 0 | 0 | 60 | 9 | 8 | 20 | 3 | 3 | -3 | 1 | 1 |
| RawSugar | | | | 0 | 0 | 0 | -2 | 1 | 1 | | | | 0 | 0 | 0 | -2 | 1 | 1 |
| OtherCrops | 23 | 1 | 2 | 1 | 0 | 0 | -1 | 1 | 1 | 6 | -3 | -3 | 1 | 0 | 0 | -1 | 1 | 1 |
| Livestock | -4 | 1 | 1 | 3 | 1 | 1 | -2 | 1 | 1 | | | | 3 | 1 | 1 | -2 | 1 | 1 |
| RawAnimalProducts | 22 | 4 | 5 | 2 | 1 | 1 | -2 | 1 | 1 | 5 | 0 | -1 | 2 | 1 | 1 | -2 | 1 | 1 |
| OilMinerals | -6 | 0 | 1 | 1 | -1 | -1 | -5 | 0 | 1 | 26 | 2 | 1 | 7 | 0 | 0 | -4 | 0 | 1 |
| LightManufacturing | 48 | 0 | -3 | 0 | 1 | 1 | -5 | 0 | 0 | 159 | 62 | 61 | 5 | 3 | 3 | -4 | 0 | 1 |
| AgriIndustriesExp | 59 | 2 | 1 | 0 | 0 | 0 | -4 | 0 | 1 | 30 | 4 | 4 | 3 | 1 | 1 | -4 | 1 | 1 |
| WoodProductsPaper | 23 | 4 | 4 | -1 | 0 | 0 | -4 | 0 | 1 | 11 | -1 | -1 | 0 | 0 | 0 | -4 | 0 | 1 |
| ChemicalsOilPr | 18 | 5 | 3 | -2 | -1 | 0 | -4 | 0 | 1 | 9 | -1 | -1 | -2 | -1 | 0 | -4 | 0 | 1 |
| MetalMineralProducts | 24 | 3 | 2 | -4 | -1 | -1 | -5 | 0 | 1 | 15 | 0 | -1 | -2 | -1 | -1 | -4 | 0 | 1 |
| MachineryEquipment | 42 | 5 | 3 | -12 | -2 | -1 | -6 | 0 | 1 | 11 | -1 | -2 | -10 | -1 | -1 | -5 | 0 | 1 |
| OtherServices | | | | 1 | 0 | 0 | -4 | 0 | 1 | | | | 1 | 0 | 0 | -4 | 0 | 1 |
| Construction | -14 | 2 | 3 | 0 | 0 | 0 | -3 | 0 | 1 | 8 | -1 | -1 | 0 | 0 | 0 | -3 | 0 | 1 |
| TradeCommunication | -12 | 2 | 3 | 0 | 0 | 0 | -3 | 0 | 1 | 6 | -1 | -2 | 0 | 0 | 0 | -3 | 0 | 1 |
| PublicServices | -13 | 2 | 3 | 0 | 0 | 0 | -3 | 0 | 1 | 7 | -1 | -2 | 0 | 0 | 0 | -3 | 0 | 1 |
| Agri | 6 | -2 | -1 | 2 | 1 | 1 | -2 | 1 | 1 | 22 | 1 | 0 | 3 | 1 | 1 | -2 | 1 | 1 |
| Non-Agri | 21 | 3 | 3 | -1 | 0 | 0 | -4 | 0 | 1 | 21 | 3 | 2 | 0 | 0 | 0 | -4 | 0 | 1 |
| Economywide | 21 | 3 | 3 | -1 | 0 | 0 | -4 | 0 | 1 | 21 | 3 | 2 | 0 | 0 | 0 | -4 | 0 | 1 |

Source: Authors' calculations.

These demand/imports side effects are linked to the supply response to which we now turn. For producers of exportable goods, the reduction of prices in local markets (ΔPd) combined with unchanged or rising export prices creates incentives to increase the share of sales destined to foreign markets. This export response (shown in the columns "Export Volumes") varies across sectors and it is linked to the pattern of Brazil's comparative advantage and to the increase in international prices. Brazil's comparative advantage can be ascertained by considering the export orientation (Exports / Dom Output) column in Table 8, which highlights three sectors in particular: Oilseeds, Other Crops, and the Agricultural transformation industry. These sectors – which also enjoy large jumps in their international price – experience export surges. Due to the generally positive export price shocks, other sectors join in an overall expansion of supply to foreign markets. Rising export sales more than offset, or at least compensate, reductions of domestic sales and lead to changes observed in the columns labeled "Domestic Output". Finally output price changes (in the rightmost columns) are in between those of domestic prices and those of export prices for the simple reason that output prices are a combination (CET prices) of (generally) rising export prices and domestic prices.

As for the demand side, similar across-scenarios differences are observed for the supply side. In particular, given the closure rule for the foreign market, economy wide increases of import volumes are balanced by a comparable increase in exports.[33]

In summary, trade reforms promote a production structure specialized towards exportables, which in Brazil is translated in a specialization towards primary or agricultural transformation sectors. This agriculture export-led boom is fully achieved only in the full liberalization scenario, given its stronger price changes and the elimination of tariffs.[34]

The full liberalization and the two Doha scenarios entail trade policy reforms that combine, in different proportions, domestic tariff abatement with external price and quantity shocks. It has been shown that, in most situations, unilateral liberalization is beneficial; however it may be of interest, especially from a negotiation point of view, to decompose the total effect and ascertain the shares attributable to domestic liberalization and to external shocks. Given the interactions between Brazilian domestic policies and the Rest of the World (ROW) policies, a decomposition exercise is path dependent, therefore the shares attributed to one set of policy or the other will differ according to the choice in their sequencing.

[33] Due to the closure rule of the external account, namely the fixing of foreign savings, and the full employment assumption, the slightly lower expansion of the volumes of exports, with respect to import volumes is compensated with a real exchange rate appreciation which originates from rising domestic resource costs.

[34] It should be stressed that in our model trade opening only produces allocative efficiency gains and not other, potentially much stronger, dynamic productivity gains.

*Table 10: Effects on imports, exports and real GDP due to combined or partial shock (Indices, BaU = 100 in 2015)*

| | Demand side | | | Supply side | | | "Welfare" | | |
|---|---|---|---|---|---|---|---|---|---|
| | Import Volumes | | | Export Volumes | | | Real GDP | | |
| | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha | Full Liber. | Deep Doha | Weak Doha |
| Combined (Own + Rest of the World liberalization) shock --- BaU = 100 | | | | | | | | | |
| Agri | 105.7 | 98.3 | 99.1 | 122.4 | 100.7 | 100.2 | 102.9 | 100.0 | 99.9 |
| Non-Agri | 121.3 | 103.3 | 102.7 | 121.0 | 102.7 | 102.0 | 100.1 | 100.0 | 100.0 |
| Economywide | 120.8 | 103.1 | 102.5 | 121.2 | 102.5 | 101.8 | 100.2 | 100.0 | 100.0 |
| Own shock --- BaU = 100 | | | | | | | | | |
| Agri | 107.3 | 98.9 | 99.8 | 114.5 | 100.8 | 100.2 | 102.0 | 100.2 | 100.0 |
| Non-Agri | 113.1 | 100.8 | 100.2 | 116.6 | 101.0 | 100.3 | 100.2 | 100.0 | 100.0 |
| Economywide | 112.9 | 100.8 | 100.2 | 116.4 | 101.0 | 100.3 | 100.3 | 100.0 | 100.0 |
| Rest of the World shock --- BaU = 100 | | | | | | | | | |
| Agri | 96.8 | 99.4 | 99.4 | 107.1 | 99.9 | 99.9 | 101.0 | 99.8 | 99.8 |
| Non-Agri | 107.5 | 102.4 | 102.4 | 104.2 | 101.7 | 101.7 | 99.9 | 100.0 | 100.0 |
| Economywide | 107.1 | 102.3 | 102.3 | 104.4 | 101.5 | 101.6 | 100.0 | 100.0 | 100.0 |

Note: For each variable, these indices are calculated as the ratio of the level in the trade scenarios to that of the BaU scenario for the last year (2015) and multiplied by 100. Source: Authors' calculations.

For three key variables, Table 10 shows the effects of the total and partial shocks as indices calculated on the levels reached in the final year, with the final year for the BaU equal to 100. In the case of the full liberalization scenario and across all variables, own liberalization accounts for a large share of the total shock. Imports in agriculture actually increase more in the partial own liberalization shock than in the combined shock, given that the external shock drives international agricultural prices up. The reduction of the mentioned anti-(agriculture-)export bias implicit in the initial protection, is also explaining the large share of export and real GDP effects accounted by the own liberalization shock.

Decomposition results for the Doha scenarios are less clear cut. The magnitudes of the shocks are much smaller, however even the very low levels of domestic tariff abatement seem to matter for the final result. A relevant policy lesson emerges from the comparison of the two partial shocks panels of Table 10: a passive non reciprocating attitude may bring some advantages; however these are quite limited, even in the extreme case where every one in the world but Brazil implements full liberalization. In fact, these externally-induced benefits may be greatly enhanced by an active domestic liberalization reform.

For their poverty and income distribution implications, changes in factors' markets are the most important aspect of the structural adjustment caused by trade reform. Changes in wages and sectoral employment are linked to changes of goods prices through the production technology and the functioning of the factor markets. Different production technologies are approximated by different factor's intensities across sectors, as shown in Table 4, and labor markets function so as to mimic realistic adjustment possibilities:

skilled workers can freely move across all sectors, whereas unskilled ones face two segmented markets and can just imperfectly migrate from the agricultural to the non agricultural segment.

*Table 11: Factor markets effects*

| | Employment | | Wages | | Unskilled Lab Migration as % of: | | Cumulative Migration | Unskilled employment |
|---|---|---|---|---|---|---|---|---|
| | Skilled | Un-skilled | Skilled | Un-skilled | Sending Pop | Receiv-ing Pop | 2001-2015 | 2015 |
| | Yearly growth rates | | | | Yearly % | | Millions | % |
| **Business as Usual:** | | | | | | | | |
| Agri | | 0.02 | | 1.68 | 1.66 | | -4.04 | 21.51 |
| Non-Agri | | 2.20 | | 0.91 | | 0.53 | 4.04 | 78.49 |
| Economywide | 2.0 | 1.7 | 1.26 | | | | | |
| **Full Liberalization:** | | | | | | | | |
| Agri | | 0.18 | | 2.10 | 1.51 | | -3.71 | 21.99 |
| Non-Agri | | 2.15 | | 1.07 | | 0.49 | 3.71 | 78.01 |
| Economywide | 2.0 | 1.7 | 1.32 | | | | | |
| **Deep Doha:** | | | | | | | | |
| Agri | | 0.06 | | 1.78 | 1.62 | | -3.96 | 21.64 |
| Non-Agri | | 2.19 | | 0.93 | | 0.52 | 3.96 | 78.36 |
| Economywide | 2.0 | 1.7 | 1.27 | | | | | |
| **Weak Doha:** | | | | | | | | |
| Agri | | 0.06 | | 1.77 | 1.62 | | -3.96 | 21.63 |
| Non-Agri | | 2.19 | | 0.93 | | 0.52 | 3.96 | 78.37 |
| Economywide | 2.0 | 1.7 | 1.26 | | | | | |

Source: Authors' calculations.

Table 11 highlights how trade shocks affect labor market structural adjustments. Due to its agriculture boom and its increased demand for "agricultural" factors of production, the full trade liberalization induces a significant increase in the wage rate for unskilled workers. When compared with the BaU, the yearly rate of growth of wage of unskilled workers in agriculture is 0.4 percentage points higher, and this higher rate accounts for a cumulative 14 year growth of 34% much higher than the cumulative growth of 26% in the BaU. Given this wage incentive, migration decreases and about 340 thousands workers who were moving out of agriculture in the BaU scenario do not switch activity in the full liberalization case. This has some effect on the aggregate distribution of unskilled workers between agriculture and non-agriculture, as shown in the last column of Table 11.

As far as the Doha scenarios are concerned, negligible effects are recorded for the employment structure and some weak wage increase is observed for unskilled in agriculture.

## 4.4 Distributional and Poverty Results of the Trade Scenarios

Two fundamental results emerge from analyzing the micro impacts of the trade scenarios. Firstly, our initial hypothesis that trade liberalization, by working against the "natural" forces of structural change, might weaken long-term trends of poverty reduction has been discarded. Although less people migrate towards higher paid non-agricultural jobs, mainly through increased agricultural incomes, poverty is further reduced in the trade liberalization scenarios. However, and this is the second fundamental result, trade reform as envisaged in the current Doha scenarios – but even in the hypothetical full liberalization one – is not of great help in the fight against poverty and its complete eradication needs additional more targeted and possibly more costly interventions.

These two sets of results are clearly illustrated by Table 12, which shows the poverty and distributional outcomes as percentage point differences between the trade scenarios and the BaU scenario for the final (2015) year: the full liberalization scenario leads to a further reduction in the headcount poverty index of 0.5 percentage points, whereas for deep Doha scenario the effects are almost negligible.[35] Similarly the Gini index is reduced by 0.2 and 0.1 percentage points in the full liberalization and deep Doha scenarios.

*Table 12: Poverty and Distributional Impact of Trade, all households*

| | BaU 2015 | % point diff. Doha | % point diff. Full |
|---|---|---|---|
| Gini | 58.5 | -0.1 | -0.2 |
| P0 | 18.0 | -0.2 | -0.5 |
| P1 | 6.6 | -0.1 | -0.2 |
| P2 | 3.5 | 0.0 | -0.1 |

Source: Authors' calculations.

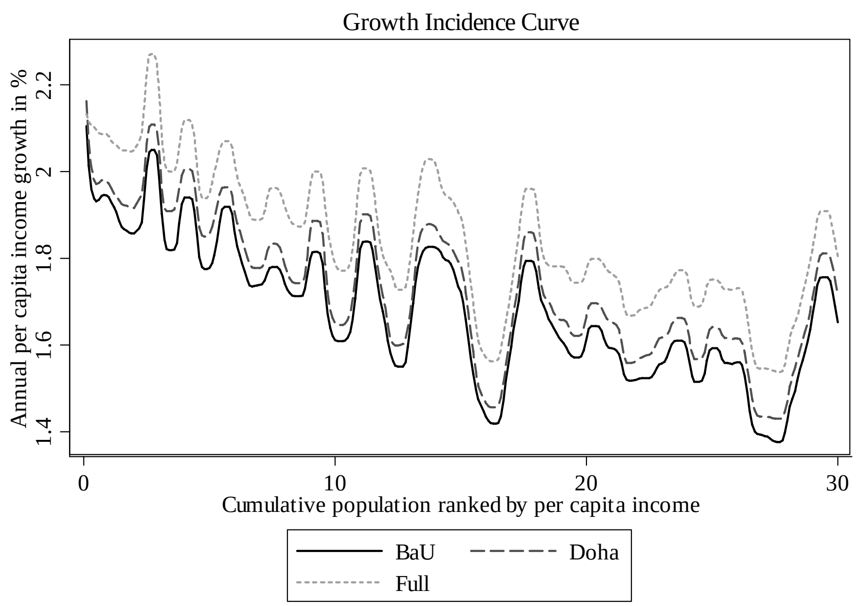
As for the BaU scenario, a thorough assessment of the trade scenarios needs to go beyond these aggregate indicators and should rely on more disaggregate poverty and distributional analyses. In search of trade-induced poverty effects, the remaining part of this section considers an array of indicators, from growth incidence curves to poverty statistics estimated on specific sub samples. In particular poverty and distributional impacts are separately measured for the agricultural and non-agricultural groups, the movers and stayers, the rural and urban populations, the regional samples, and the

[35] Given that the weak Doha scenario does not produce any visible results, in this section we just report results for the full liberalization and the deep Doha scenarios.

groupings obtained by educational attainment, by land ownership, and by occupational status.

Figure 3 shows the growth incidence curves for the poorest thirty percent of all households under the three scenarios. The curve for the deep Doha scenario lies slightly above the BaU curve. The full liberalization reform also shifts the whole curve upwards, however this shift is larger than that of the Doha case, and it seems to favor the poorest among the poor; in other words, full liberalization appears to induce an additional pro-poor distributional shift.

*Figure 3: Growth incidence curves for the BaU and Trade scenarios, poorest 30 percent of all households*




Source: Authors' calculations.

Table 13 shows the sectorally disaggregated results. Inequality for all households falls due to decreased inequality among agricultural households and lower inequality increase among non-agricultural households, although inequality between these two groups may have risen somewhat. Despite declining inequality and slightly higher per capita income growth, poverty reduction for agricultural households barely changes and this is due, as shown below, by the lower migration levels induced by the trade shocks. Indeed, in the deep Doha scenario the reduction in the population share of agricultural households is only very slightly below that achieved in the BaU. More remarkable is the additional poverty reduction for non-agricultural households that can largely be explained by the lower increase in inequality, as per capita income growth is only marginally higher.

*Table 13: Poverty and inequality in the Doha scenario, by sector*

| | All households | | | Non-agricultural households | | | Agricultural households | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2001 levels | 2001-15 changes | % of BaU change | 2001 levels | 2001-15 changes | % of BaU change | 2001 levels | 2001-15 changes | % of BaU change |
| PC income | 314.9 | 1.5 | 101.5 | 351.9 | 1.3 | 102.1 | 148.3 | 2.4 | 101.3 |
| Gini | 58.6 | -0.2 | 194.4 | 57.1 | 0.5 | 81.8 | 56.6 | -0.8 | 111.5 |
| P0 | 23.6 | -5.8 | 103.4 | 18.6 | -3.3 | 106.5 | 46.2 | -14.0 | 101.5 |
| P1 | 9.6 | -3.1 | 102.7 | 7.1 | -1.6 | 104.6 | 21.0 | -8.2 | 102.1 |
| P2 | 5.3 | -1.9 | 102.5 | 3.7 | -0.9 | 104.3 | 12.3 | -5.3 | 102.0 |
| Population % | 100.0 | | | 81.8 | 3.2 | 98.3 | 18.2 | -3.2 | 98.3 |
| Contr. to P0 | | | | 64.4 | 8.6 | 96.0 | 35.6 | -8.6 | 96.0 |

Source: Authors' calculations.

Given its larger price and quantities shocks, the full liberalization scenario yields more significant poverty changes, as shown in Table 14. In contrast to the Doha scenario, agricultural households gain considerably from full liberalization and their headcount index is reduced by almost 1.5 percentage points. This sector specific income gains more than compensate the further (albeit small) reduction of agricultural out-migration.

For non-agricultural households, the full liberalization scenario improves the income distribution, the Gini increases by only 72 per cent of the increase recorded in the BaU. Growth is only slightly higher for this group of households but, as shown above, minor distributional shifts accompanied by slightly higher growth can result in significant poverty reduction.

*Table 14: Poverty and inequality in the Full scenario, by sector*

| | All households | | | Non-agricultural households | | | Agricultural households | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2001 levels | 2001-15 changes | % of BaU change | 2001 levels | 2001-15 changes | % of BaU change | 2001 levels | 2001-15 changes | % of BaU change |
| PC income | 314.9 | 1.6 | 106.4 | 351.9 | 1.3 | 106.8 | 148.3 | 2.6 | 109.8 |
| Gini | 58.6 | -0.3 | 312.2 | 57.1 | 0.5 | 72.0 | 56.6 | -0.9 | 117.0 |
| P0 | 23.6 | -6.1 | 109.2 | 18.6 | -3.6 | 116.3 | 46.2 | -14.9 | 108.0 |
| P1 | 9.6 | -3.2 | 108.2 | 7.1 | -1.8 | 113.7 | 21.0 | -8.6 | 107.4 |
| P2 | 5.3 | -1.9 | 107.8 | 3.7 | -1.0 | 113.0 | 12.3 | -5.6 | 107.2 |
| Population % | 100.0 | | | 81.8 | 3.1 | 93.0 | 18.2 | -3.1 | 93.0 |
| Contr. to P0 | | | | 64.4 | 8.4 | 96.0 | 35.6 | -7.6 | 96.0 |

Source: Authors' calculations.

Trade shocks simultaneously increase agricultural incomes and reduce inter-sectoral migration and how these two contrasting forces affect poverty outcome depends on the income levels (and therefore on the socio-economic characteristics) of those who decide to stay instead of moving. The next set of tables sheds some light on this issue.

Table 15 shows the poverty levels and changes under the BaU and the trade scenarios for agricultural households who *remained* in agriculture. First consider the BaU case. Having identified those households that will not move, it is possible to calculate the headcount for this group in the initial year (2001): their headcount is equal to 44.1% more than 2 percentage points below the 46.2 level[36] calculated for all 2001 (stayer and potential mover) agricultural households. This lower *level* of poverty implies that moving households are on average poorer than those who remain in agriculture. Accordingly, the *changes* in P0 are 12.1 instead of 13.7 percentage points. In 2015, about 15 percent of the population still live in agricultural households.[37] The agricultural expansion following trade liberalization has only a minor effect on agricultural employment, by far not enough to offset the reduction in agricultural employment from the BaU. Accordingly, the change of the share of agricultural households due to trade liberalization is only minor, in particular for the Doha scenario. Yet, when translated in actual migrating individuals, this small share change means that almost four hundred thousand individuals – who would have become members of non-agricultural households in the BaU – in the full liberalization scenario remain in agricultural households. Despite the fact that these "potential mover households" are on average poorer than the typical "stayer household", as we illustrate below, poverty among agricultural households decreases compared to the BaU. The poor stayers hence gain under both trade scenarios although this gain is almost negligible for the Doha scenario.

*Table 15: Poverty impact of trade, agri stayers*

| | Households remaining in agri | | | |
|---|---|---|---|---|
| | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change |
| P0 | 44.1 | -11.7 | 101.7 | 109.5 |
| P1 | 20.0 | -7.0 | 102.4 | 108.5 |
| P2 | 11.7 | -4.6 | 102.3 | 108.2 |
| Population % | | 14.9 | 100.4 | 101.5 |

Source: Authors' calculations.

As could be indirectly inferred from the analysis of the stayers, the group of the movers should experience the largest welfare gains. Indeed as illustrated in Table 16, in the BaU agricultural households who become non-agricultural households record a 22.4 percentage points reduction in their headcount index, down from a considerably high, especially in comparison to the stayers group, initial level of 56.6 percent.

[36] Shown in Table 5.

[37] The initial poverty levels among those who stay in agriculture under the trade scenarios are almost identical to the initial levels among the BaU stayers, so we decided not to report them. The same holds for the movers, for whom we report results later.

This outcome could not be derived straightforwardly from the estimation of the migration choice. In fact, the estimations showed that potential migrants were found to be poorer, in particular landless, heads, but also better educated, hence less poor, non-heads. The explicit quantitative measurements allowed by micro-simulation were needed to highlight the poverty reducing role of changes in the sectoral composition of employment.

In the trade scenarios, a moderately additional poverty reduction is observed. This is due to the income increases trade reforms induce in the non-agriculture sectors, but also because the fewer households that still move out of agriculture under the trade scenarios are actually poorer.

*Table 16: Poverty impact of trade, sectoral movers*

| | Agri households who have become non-agri | | | |
|---|---|---|---|---|
| | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change |
| P0 | 56.6 | -22.4 | 105.1 | 108.2 |
| P1 | 26.0 | -14.0 | 102.0 | 105.4 |
| P2 | 15.2 | -9.4 | 101.7 | 105.1 |
| Population % | | 3.1 | 98.0 | 92.5 |

Source: Authors' calculations.

One final category needs to be examined: the non-agricultural stayers. Representing 80 percent of the population, this is a large group; however, given the negligible migration out of the non-agricultural sector observed in the data, this group is explicitly excluded from the migration choice. For these households, the full liberalization brings about an additional reduction in the headcount of 0.4 percentage points, and through its favorable impact on non-agricultural unskilled wages the Doha scenario, too, makes a small but noticeable difference.

*Table 17: Poverty impact of trade, non-agri stayers*

| | Non-agri households before and after | | | |
|---|---|---|---|---|
| | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change |
| P0 | 18.6 | -3.8 | 104.0 | 110.7 |
| P1 | 7.1 | -1.8 | 103.3 | 109.8 |
| P2 | 3.7 | -1.0 | 103.2 | 109.5 |
| Population % | 82.4 | | | |

Source: Authors' calculations.

Up to this point, the disaggregated analysis of the poverty impacts has been based on sectoral affiliation and thus it has been possible to link it directly to the sectoral results generated by the CGE model. However, additional policy relevant criteria can be used to identify other groups of households and to evaluate their specific trade induced poverty effects. In particular, we conduct impact analyses for rural and urban areas, by regions, by land ownership, by educational level and by occupation. Obviously, all these criteria are somehow correlated to basic categories included in the CGE model, for example the educational level is linked to the skilled/unskilled factor types, or the region to the prevalence of agricultural employment, but strict correlation should not limit the micro analysis. Using the full household survey information provides maximum flexibility and allows extracting ex-post additional information. Instead of roughly inferring the poverty impact on certain groups from correlations between the rigidly CGE embedded categories and micro characteristics, the generated counterfactual income distributions contain all the information needed and hence directly provide a quantitative assessment of the poverty impact on specific groups.

*Table 18: Poverty and inequality impact of trade, urban and rural*

| | Urban | | | | Rural | | | |
|---|---|---|---|---|---|---|---|---|
| | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change |
| P0 | 19.6 | -4.0 | 103.8 | 112.2 | 44.4 | -12.1 | 103.1 | 108.2 |
| P1 | 7.6 | -2.0 | 103.2 | 110.1 | 20.1 | -7.1 | 102.5 | 108.2 |
| P2 | 4.0 | -1.2 | 103.0 | 109.5 | 11.7 | -4.7 | 102.3 | 107.7 |
| Population % | 83.7 | 1.3 | 99.5 | 93.2 | 16.3 | -1.3 | 99.5 | 93.2 |
| Contr. to P0 | 69.4 | 3.9 | 96.6 | 35.5 | 30.6 | -3.7 | 102.3 | 119.8 |

Source: Authors' calculations.

Table 18 shows the poverty impact of trade by urban or rural residence. Interestingly, the share of urban households in 2001 (83.7 percent) is even higher, although not much, than the share of non-agricultural households (81.8 percent). Quite some households live in urban areas, very likely in urban peripheries, and earn their living primarily from agricultural wage-employment. Actually, only 66 percent of the agricultural households live in rural areas, while 5 percent of the non-agricultural households live in rural areas. The micro-simulations that generate the results of Table 18 also take into account rural-urban migration by assuming that households migrate to urban areas if *all* employed household members leave agriculture. In the BaU, this causes the rural population to decline by 1.3 percentage points. The urban population accounts for almost 70 percent of the Brazilian poor in 2001 and this share rises in the BaU by 3.9 percentage points. Urban poverty declines under both trade scenarios with the decline being stronger under the full liberalization scenario. The Doha scenario hardly affects rural poverty, but full liberalization decreases the rural headcount by an additional percentage point. Some simple calculations can give some more meaning to these figures: The 0.5 percentage point difference in P0 in the full liberalization scenario means that approximately 135,000 people are lifted out of poverty. The 1 percentage point difference implied by the full liberalization scenario reduces the number of poor people in rural areas by approximately 115,000. Considering the very small increase in non-agricultural unskilled wages this may be somewhat surprising, but it is the urban concentration that drives this result. Some more growth in urban areas lifts more people out of poverty than very high agricultural growth.

*Table 19: Poverty impact of trade, by region*

| | 2001 initial levels | | | 2015 | | |
|---|---|---|---|---|---|---|
| Region | Population % | P0 | % contr. to P0 | BaU 2001-15 P0 change | Doha % of BaU P0 change | Full % of BaU P0 change |
| North | 5.7 | 34.0 | 8.2 | -7.9 | 101.0 | 107.7 |
| Northeast | 28.5 | 45.4 | 54.8 | -9.3 | 102.6 | 109.5 |
| Southeast | 43.5 | 12.4 | 22.8 | -3.7 | 101.9 | 107.9 |
| South | 15.2 | 14.7 | 9.5 | -4.6 | 101.4 | 107.8 |
| Center-West | 7.1 | 16.0 | 4.8 | -5.0 | 119.4 | 121.3 |

Source: Authors' calculations.

Due to the regional differences both in factor endowments and specialization patterns, we might expect poverty reduction patterns to differ substantially between the regions for the BaU as well as for the trade shocks. The reduction in the headcount for the BaU confirms this expectation, as poverty declines more strongly in the Northeast, South, and Center-West, the regions with the highest shares in agricultural employment. The Doha round has negligible effects across all regions although the figures in Table 19 suggest a different story for the Center-West. Yet, a look at the changes of P1 and P2 (not reported) demonstrates that this strong effect is due to many households being just below the poverty line in this region.[38] The Northeast, the region with the highest incidence of poverty where more than 50 percent of the Brazilian poor reside, benefits most from the Doha liberalization and about 50 000 individuals are lifted out of poverty in this region. In the same region, full liberalization helps about 175 000 individuals to escape poverty. The poor in the North, another region with worryingly high poverty rates, gain relatively

[38] This is a case that illustrates why we usually report not only the headcount index, as this indicator can be quite misleading in some instances.

little from trade liberalization, whereas poverty in the South as well as in the Center-West decreases quite substantially due to the importance of agricultural income for the poor in these regions.

*Table 20: Poverty impact of trade, agricultural stayers by owning land*

| | Landowner households | | | | No land owning households | | | |
|---|---|---|---|---|---|---|---|---|
| | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change | 2001 levels | BaU 2001-15 changes | Doha % of BaU change | Full % of BaU change |
| P0 | 37.1 | -10.5 | 101.7 | 108.0 | 48.5 | -12.5 | 101.9 | 110.6 |
| P1 | 16.6 | -6.2 | 102.7 | 109.1 | 22.2 | -7.4 | 102.3 | 108.4 |
| P2 | 9.5 | -3.9 | 102.7 | 109.4 | 13.1 | -5.0 | 102.2 | 107.8 |
| Population % | 38.4 | | | | 61.6 | | | |

Source: Authors' calculations.

Table 20 shows the poverty changes for landowners and agricultural households who do not own land separately. The landowning households account for approximately 40 percent of the population in agricultural households. The differences between the two groups of agricultural households are quite striking. The poverty incidence among landowning households is much lower; the difference is more than 10 percentage points. Poverty decreases quite substantially for both groups in the BaU. Note that we only consider households who stay in agriculture. Poor households who do not own land benefit little from the Doha round, but full liberalization brings about an additional decrease of more than 1 percentage point in the headcount (affecting almost 100 000 individuals). The reason why they benefit more from both trade scenarios is that they are more specialized in agricultural income. This is not necessarily what one would expect, but it may well be that owning land provides the resources to set up a small non-agricultural business. Noteworthy is the finding that under both trade scenarios poverty gap as well as severity index decrease stronger than the headcount in terms of the BaU change. This again has to do with the specialization of households. The poorer landowning households derive a higher share of their income from agriculture whereas the richer households (at least among the poor) earn a higher share of income from non-agricultural activities.

*Table 21: Poverty impact of trade, by educational levels*

| Hh. average schooling | 2001 initial levels Population % | P0 | % contr. to P0 | 2015 Population % | BaU 2001-15 P0 change | Doha % of BaU P0 change | Full % of BaU P0 change |
|---|---|---|---|---|---|---|---|
| <= 3 | 16.2 | 52.3 | 35.9 | 16.0 | -10.7 | 103.5 | 111.5 |
| <=5 | 16.9 | 36.0 | 25.7 | 16.6 | -9.1 | 102.9 | 109.9 |
| <=8 | 20.9 | 21.1 | 18.7 | 20.7 | -5.6 | 105.0 | 111.5 |
| <=10 | 12.9 | 11.3 | 6.2 | 12.9 | -2.9 | 104.6 | 111.3 |
| >=11 | 33.1 | 9.6 | 13.5 | 33.7 | -2.0 | 101.7 | 104.6 |

Source: Authors' calculations.

As Table 21 indicates, the educational level of the households is an important determinant of poverty. The headcount among households with 3 or less average years of schooling of the employed household members is well above 50 percent. This group accounts for 16.2 percent of the population but for more than a third of the poor. The poverty incidence among households with 4 or 5 years of schooling is 15 percentage points lower. For both groups with 'ten' or 'more than ten' years of average schooling, the headcount is about 10 percent. The Doha round does not appear to be particularly helpful for those with little educational endowment. Yet, the full liberalization scenario again leads to a substantial additional reduction in poverty.

Finally, we analyze the poverty impact of trade reform by occupational groups. In Table 22 we differentiate between wage-employed, self-employed and households with members engaged in both types of employment in agricultural and non-agricultural activities, respectively.[39] In addition, there are households with no employed household member. One out of five poor people in Brazil comes from a self-employed agricultural household, and the agricultural wage-employed households are almost equally poor. In non-agricultural households, the difference between self-employed and wage-employed households in terms of poverty is not too pronounced. Due to their high share in the population, non-agricultural wage-employed households account for more than a third of the Brazilian poor. Poverty rates are significantly lower for households who derive their income from both wage-and self-employment. Under the Doha scenario, all non-agricultural household groups gain, whereas there are only minor gains for agricultural households. As noted above, full liberalization however helps both agricultural and non-agricultural households. Interestingly, poverty in non-agricultural activities declines more

[39] If the number of self-employed household members is greater than the number of wage-employed members, the household is considered self-employed, and vice versa. Are the numbers equal, the households falls under the "both" category.

among the self-employed, whereas in agricultural activities the decline is stronger for the wage-employed. As in the case of households who do not own land, the agricultural wage-employed households derive more income from agricultural unskilled labor than agricultural self-employed households. For non-agricultural households, it is the greater importance of skilled income for the wage-employed that makes poverty decline less strongly for this group.

*Table 22: Poverty impact of trade, by occupation*

| | 2001 initial levels | | | BaU 2001-15 | | Doha 2001-15 | | Full 2001-15 | |
|---|---|---|---|---|---|---|---|---|---|
| | Population % | P0 | % contr. to P0 | Population % change | P0 change | Population % change | % of BaU P0 change | Population % change | % of BaU P0 change |
| Agri wage-empl. | 5.6 | 46.2 | 11.0 | -1.5 | -14.3 | -1.5 | 101.5 | -1.4 | 111.2 |
| Agri self-empl. | 10.2 | 48.0 | 20.7 | -1.3 | -13.7 | -1.3 | 101.4 | -1.2 | 106.7 |
| Agri both | 2.4 | 38.8 | 3.9 | -0.5 | -14.1 | -0.5 | 101.3 | -0.5 | 105.5 |
| Not empl. | 7.8 | 27.4 | 9.1 | 0.0 | -4.3 | 0.0 | 100.0 | 0.0 | 100.0 |
| Non-agri wage | 48.5 | 17.2 | 35.3 | 1.6 | -3.1 | 1.6 | 107.2 | 1.5 | 117.4 |
| Non-agri self | 15.9 | 22.7 | 15.3 | 1.1 | -2.9 | 1.1 | 107.9 | 1.1 | 121.0 |
| Non-agri both | 9.6 | 11.5 | 4.7 | 0.6 | -2.3 | 0.6 | 108.0 | 0.5 | 123.4 |

Source: Authors' calculations.

To sum up, the poverty changes under the deep Doha scenario are rather moderate and disappointing. With one exception, our analyses do not detect a particularly favorable effect on any of the poor and vulnerable groups that we have identified. This one exception is that the Doha scenario very slightly appears to favor the Northeast. Overall, income growth under the Doha scenario favors non-agricultural activities and, accordingly, urban areas. Since the population is concentrated in urban areas, some growth can already reduce poverty considerably, in particular if accompanied by a pro-poor distributional shift, as in the Doha scenario. Our analyses show that anti-poor changes in the distribution can easily dwarf the poverty reducing potential of growth. The income growth pattern under full liberalization tends to favor poor groups. Poor agricultural and less educated households benefit considerably more from full liberalization than from the Doha liberalizations.

# 5 Conclusions

Our analysis is centered on the contributions to poverty reduction of one key long-term trend observed in the labor markets of many developing countries: the movement of workers out of agriculture and the consequent increase of the employment shares of the non-farm sectors of the economy. Econometric estimates for Brazil show that, with few exceptions, poorer individuals are more likely to migrate to non-farm occupations – which on average offer much higher earnings than farm ones – and thus provide direct evidence that finding a job in the non-farm segment is a main road out of poverty. The data also highlight some of the major factors that increase individuals' likelihood of moving and knowledge of these factors may offer some preliminary guidance for policy interventions aimed at reducing poverty. In particular, imperfections in the capital markets (especially in the land market) and low education seem to act as traps and reduce the probability of migrating.

By embedding these *ex-post* estimations in an income generation microsimulation model and by linking the latter to a computable general equilibrium model, we are also able to produce some interesting *ex-ante* policy scenario analysis. The focus is on trade policy, but the methodology developed here may be applied to evaluate other policy reforms. In our simulation setting we 'test' and reject the hypothesis that trade liberalization, by reducing labor migration out of agriculture, might weaken long-term trends of poverty reduction. In the trade reforms scenarios, as those envisaged in the current Doha negotiations as well as in the hypothetical full liberalization one, a larger number of workers remain in agriculture compared to Business as Usual scenario. However, as the trade-related gains in agricultural incomes more than compensates for the reduced benefits of lower migration flows, more people are able to escape poverty. The positive impact of liberalization is not limited to rural areas and agricultural activities. The urban poor gain from higher incomes for unskilled labor, even in non-agricultural sectors, and from the related pro-poor shift in the urban income distribution. In addition, the urban poor benefit indirectly from the gains in agriculture and the connected lower migration towards non farm activities, as downward the pressure on the wages of non-agricultural unskilled workers is relieved somewhat. Trade reforms add very little to the BaU's 6 percentage point reduction of poverty incidence, from 23% in 2001 to 17% in 2015. Full liberalization cumulative final effect is just an additional reduction of half a percentage point and the most generous Doha deal is half of the full liberalization effect. Trade reform, and in particular domestic trade reforms, may particularly help the Brazilian poor farmers, but only broad-based high growth, and possibly additional more targeted and more costly pro-poor interventions, will eradicate urban poverty.

An important limitation of our analysis is that we do not assume any dynamic gains from trade liberalization. Our results might hence be taken as a lower bound of the welfare effects, as there is strong evidence of a beneficial impact of trade liberalization on productivity (Winters, McCulloch, and McKay 2004). We also acknowledge that our representation of urban labor markets may be too simple to evaluate the effects of trade reform on the poorest groups in urban areas, who are largely engaged in the informal sector. Unfortunately, given the paucity of hard data on the size and behavior of the informal economy, our model does not explicitly account for it. This may be a serious limitation especially with regard to the analysis of trade shocks. In fact, due to their dissimilar technologies and trade-orientation, informal and formal activities may be affected in very different ways by trade reforms. Similarly, the exogenous human capital upgrading implemented in our model is a rather strong simplification of the complex endogenous education decision process happening in reality, so some of its more subtle income distribution effects may be lost.

Notwithstanding these limitations and although more data and computation intensive, the macro-micro modeling approach developed for this study has many advantages over simpler more aggregate methods. In particular, our framework can be used to do decomposition analyses and assess the relative importance of changes of per capita average incomes versus changes in inequality. In other words, we can identify and measure more precisely how policy shocks are transmitted to the various households and how households' specific socio-economic characteristics affect the final poverty outcomes. For Brazil, the majority of the BaU's decline of poverty is due to poverty reduction in agriculture and this is attributable to factor price changes (higher wages). Additional portions of poverty reduction are due to the exit of labor from agriculture (especially important for the poorer among the poor), and finally to skill upgrading.

Having at our disposal counterfactual income distributions that contain all the relevant information on socio-economic characteristics, our post-simulation analyses can provide quantitative assessment of the poverty impact on many specific groups, without the limitations of the initial, often fairly limited, groups of household included in the CGE model.

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# 7 Appendices

## 7.1 Estimation results, mover-stayer model

### Mover-stayer model for heads, Logit estimates

| | | |
|---|---|---|
| Number of obs | = | 6726868.000 |
| Wald chi2(6) | = | 197.120 |
| Prob > chi2 | = | 0.000 |
| Pseudo R2 | = | 0.068 |

Log pseudo-likelihood = -655384.78

| | *Coef.* | *Robust Std. Err.* | *z* | *P>\|z\|* | *[95% Conf.* | *Interval]* |
|---|---|---|---|---|---|---|
| dedu | 0.419 | 0.278 | 1.510 | 0.132 | -0.126 | 0.963 |
| age | -0.044 | 0.005 | -9.490 | 0.000 | -0.053 | -0.035 |
| ddworkown | -1.123 | 0.319 | -3.520 | 0.000 | -1.749 | -0.497 |
| dcess | -0.825 | 0.327 | -2.530 | 0.012 | -1.466 | -0.185 |
| dprop | -0.736 | 0.172 | -4.280 | 0.000 | -1.074 | -0.399 |
| dgregio1 | 0.593 | 0.202 | 2.930 | 0.003 | 0.196 | 0.990 |
| _cons | -1.708 | 0.178 | -9.580 | 0.000 | -2.058 | -1.359 |

### Changes in Predicted Probabilities for Moving out of Agriculture

| | *0->1* | *-+sd/2* | *MargEfct* |
|---|---|---|---|
| dedu | 0.008 | | 0.007 |
| age | | -0.011 | -0.001 |
| ddworkown | -0.012 | | -0.018 |
| dcess | -0.009 | | -0.013 |
| dprop | -0.010 | | -0.012 |
| dgregio1 | 0.012 | | 0.009 |

Source: Authors' calculations. Note:

| | |
|---|---|
| dedu: | educational dummy for 10 or more years of schooling |
| ddworkown: | dummy for own-consumption workers |
| dcess: | holding ceded land |
| dprop: | holding own land |
| dgregio1: | north. |

**Mover-stayer model for non-heads, Logit estimates**

| | | |
|---|---|---|
| Number of obs | = | 8166562 |
| Wald chi2(6) | = | 293.58 |
| Prob > chi2 | = | 0.000 |
| Pseudo R2 | = | 0.152 |

Log pseudo-likelihood = -639678.55

| | *Coef.* | *Robust Std. Err.* | *z* | *P>\|z\|* | *[95% Conf.* | *Interval]* |
|---|---|---|---|---|---|---|
| dprim3 | 0.782 | 0.229 | 3.410 | 0.001 | 0.332 | 1.232 |
| dsec1 | 0.633 | 0.298 | 2.120 | 0.034 | 0.049 | 1.218 |
| dsec2 | 0.597 | 0.324 | 1.840 | 0.066 | -0.039 | 1.232 |
| exp | 0.101 | 0.023 | 4.340 | 0.000 | 0.055 | 0.146 |
| exp2 | -0.002 | 0.000 | -4.270 | 0.000 | -0.003 | -0.001 |
| gend | -0.759 | 0.188 | -4.030 | 0.000 | -1.127 | -0.390 |
| preta | -0.500 | 0.336 | -1.490 | 0.137 | -1.159 | 0.159 |
| ddnonrem | -0.849 | 0.171 | -4.960 | 0.000 | -1.185 | -0.513 |
| ddworkown | -1.731 | 0.307 | -5.640 | 0.000 | -2.332 | -1.130 |
| dprop | -1.839 | 0.462 | -3.980 | 0.000 | -2.745 | -0.934 |
| headnagr | 1.122 | 0.167 | 6.710 | 0.000 | 0.794 | 1.450 |
| headmover | 2.468 | 0.374 | 6.610 | 0.000 | 1.736 | 3.200 |
| _cons | -4.369 | 0.298 | -14.640 | 0.000 | -4.954 | -3.783 |

**Changes in Predicted Probabilities for Moving out of Agriculture**

| | *0->1* | *-+sd/2* | *MargEfct* |
|---|---|---|---|
| dprim3 | 0.010 | | 0.007 |
| dsec1 | 0.007 | | 0.006 |
| dsec2 | 0.007 | | 0.005 |
| exp | | 0.017 | 0.001 |
| exp2 | | -0.024 | 0.000 |
| gend | -0.007 | | -0.007 |
| preta | -0.004 | | -0.004 |
| ddnonrem | -0.007 | | -0.007 |
| ddworkown | -0.011 | | -0.015 |
| dprop | -0.008 | | -0.016 |
| headnagr | 0.015 | | 0.010 |
| headmover | 0.084 | | 0.021 |

Source: Authors' calculations. Note:

| | |
|---|---|
| dprim3: | 9 years of schooling |
| dsec1: | 11 or 11 years of schooling |
| dsec2: | 12 years of schooling |
| exp: | age minus schooling |
| exp2: | experience squared |
| gend: | female 1 |
| preta: | black |
| ddnonrem: | non-remunerated household member |
| ddworkown: | own-consumption worker |
| dprop: | holding own land |
| headnagr | household head in non-agricultural sector |
| headmover: | head has moved out of agriculture. |

## 7.2 Estimation results, wage/profit equations

***Note on the selectivity bias of the wage/profit equations***

Some words on the choice of this specification are in order, as estimating the two wage equations for unskilled labor using OLS may appear problematic to the reader who is familiar with the concept of selectivity bias and is aware of the available econometric methods to deal with it. The reason for estimating two wage equations is based on the assumption that the wage-setting process in agriculture is different from the one in non-agricultural sectors; and the results of our regressions confirm this assumption. When estimating two separate equations we therefore might have to account for selectivity bias. Selectivity bias refers to a bias in the coefficients of the wage equations which arises as the coefficients do not merely reflect the returns to education, seniority, or the influence of the included dummies, but also the returns of being employed in (or selected into) the respective sector. For example, having a high level of education affects the sectoral choice, i.e. the earnings indirectly, as well as the earnings directly. Applying OLS to the estimation of two separate (sectoral) wage equations would result in coefficients that reflect both the indirect (selection) and the direct effects. Selection can also be interpreted in terms of having a kind of "comparative advantage" in the chosen sector, which is not explicitly accounted for but represented by the biased OLS coefficients. Econometricians often describe the concept of selectivity by noting that the selection into the respective sectors is non-random. It has become very common to correct for selectivity bias using the so-called Heckman correction or one of its many variants.

Many authors have warned against the indiscriminate use of the selectivity correction methods.[40] In line with this general skepticism, for reasons that have to do with the purpose of estimating the above equation, and due to practical estimation problems, we believe that correcting for selectivity bias is not necessary or may even lead to wrong results in the present context. The purpose of estimating the wage equations is to impute earnings for those who move between sectors. If we estimate the wage equation using OLS we implicitly assume that the returns to education and other characteristics of the individual include the indirect returns due to selection. We believe that this can be reasonably assumed, as an individual, for whom a wage is to be imputed, is actually selected into the corresponding sector.[41] In addition, estimating a selection model rendered inconsistent results. The only feasible estimation strategy would then have been to reduce the number of explanatory variables in the wage equation to include only one educational dummy for tertiary education with the remaining educational dummies to be only included in the selection equation.[42] This of course would have been highly unsatisfactory in terms of explaining the variation in earnings. These results are mainly owed to a combination of the following two factors. First, lower levels of education are highly significant in selecting an individual into agriculture. Second, there is little

[40] See Johnston, Di Nardo (1997, pp.449-450) for a short overview of the major problems involved and the citations there.

[41] This assumption implies that there are no differences between individuals in terms of sectoral comparative advantages. If we estimated the wage equation correcting for selectivity, these differences would be reflected in the individual inverse Mills ratios.

[42] These or similar problems of applications of the Heckman procedure are often noted in applied work. A case in point is Spatz (2004).

variation in these variables for those in non-agricultural sectors. In light of these theoretical and practical arguments we used OLS rather than Heckman correction procedures.

***Results:***

**Wage/profit equation for agriculture unskilled**

| | | |
|---|---|---|
| Number of obs | = | 11093822 |
| F( 11, 3209) | = | 419.53 |
| Prob > F | = | 0.000 |
| R-squared | = | 0.3021 |
| Root MSE | = | 0.83187 |

| | *Coef.* | *Robust Std. Err.* | *t* | *P>\|t\|* | *[95% Conf.* | *Interval]* |
|---|---|---|---|---|---|---|
| edu | 0.084 | 0.003 | 27.270 | 0.000 | 0.078 | 0.090 |
| exp | 0.047 | 0.002 | 29.900 | 0.000 | 0.044 | 0.050 |
| exp2 | -0.001 | 0.000 | -28.780 | 0.000 | -0.001 | -0.001 |
| gend | -0.858 | 0.018 | -46.640 | 0.000 | -0.894 | -0.822 |
| preta | -0.138 | 0.027 | -5.050 | 0.000 | -0.191 | -0.084 |
| parda | -0.171 | 0.016 | -10.490 | 0.000 | -0.203 | -0.139 |
| nnonrem | 0.043 | 0.009 | 4.790 | 0.000 | 0.025 | 0.060 |
| drn | -0.129 | 0.049 | -2.620 | 0.009 | -0.225 | -0.032 |
| drne | -0.339 | 0.025 | -13.590 | 0.000 | -0.388 | -0.290 |
| drs | 0.150 | 0.032 | 4.720 | 0.000 | 0.088 | 0.213 |
| drcw | 0.225 | 0.036 | 6.210 | 0.000 | 0.154 | 0.297 |
| _cons | 4.079 | 0.040 | 102.470 | 0.000 | 4.001 | 4.157 |

Source: Authors' calculations. Note:

| | |
|---|---|
| edu: | years of schooling |
| exp: | age minus schooling |
| exp2: | experience squared |
| gend: | female 1 |
| preta: | black |
| parda: | mixed black |
| nnonrem: | number of non-remunerated household members |
| d*: | regional dummies with r for rural, n north, ne northeast, s south, cw center-west. |

## Wage/profit equation for non-agriculture unskilled

| | | |
|---|---|---|
| Number of obs | = | 42813743 |
| F( 16, 6514) | = | 1710.86 |
| Prob > F | = | 0.000 |
| R-squared | = | 0.423 |
| Root MSE | = | 0.67388 |

| | *Coef.* | *Robust Std. Err.* | *t* | *P>\|t\|* | *[95% Conf. Interval]* | |
|---|---|---|---|---|---|---|
| edu | 0.008 | 0.003 | 2.840 | 0.004 | 0.003 | 0.014 |
| edu2 | 0.006 | 0.000 | 33.350 | 0.000 | 0.006 | 0.007 |
| exp | 0.069 | 0.001 | 88.200 | 0.000 | 0.068 | 0.071 |
| exp2 | -0.001 | 0.000 | -68.950 | 0.000 | -0.001 | -0.001 |
| gend | -0.590 | 0.006 | -102.830 | 0.000 | -0.601 | -0.579 |
| preta | -0.148 | 0.011 | -13.460 | 0.000 | -0.169 | -0.126 |
| parda | -0.143 | 0.007 | -21.910 | 0.000 | -0.156 | -0.130 |
| dun | -0.190 | 0.013 | -15.020 | 0.000 | -0.214 | -0.165 |
| drn | -0.501 | 0.106 | -4.710 | 0.000 | -0.709 | -0.293 |
| dune | -0.450 | 0.011 | -40.590 | 0.000 | -0.472 | -0.428 |
| drne | -0.710 | 0.033 | -21.800 | 0.000 | -0.774 | -0.646 |
| drse | -0.229 | 0.029 | -7.960 | 0.000 | -0.286 | -0.173 |
| dus | -0.069 | 0.011 | -6.470 | 0.000 | -0.090 | -0.048 |
| drs | -0.171 | 0.029 | -5.950 | 0.000 | -0.227 | -0.115 |
| ducw | -0.123 | 0.013 | -9.420 | 0.000 | -0.149 | -0.098 |
| drcw | -0.383 | 0.054 | -7.040 | 0.000 | -0.490 | -0.276 |
| _cons | 4.494 | 0.020 | 227.760 | 0.000 | 4.455 | 4.533 |

Source: Authors' calculations. Note:

| | |
|---|---|
| edu: | years of schooling |
| edu2: | edu squared |
| exp: | age minus schooling |
| exp2: | experience squared |
| gend: | female 1 |
| preta: | black |
| parda: | mixed black |
| nnonrem: | number of non-remunerated household members |
| d*: | regional dummies with r (u) for rural (urban), n north, ne northeast, s south, cw center-west. |

**Wage/profit equation for skilled**

| | | |
|---|---|---|
| Number of obs | = | 15960009 |
| F( 16, 6514) | = | 995.20 |
| Prob > F | = | 0.000 |
| R-squared | = | 0.453 |
| Root MSE | = | 0.749 |

| | *Coef.* | *Robust Std. Err.* | *t* | *P>\|t\|* | *[95% Conf.* | *Interval]* |
|---|---|---|---|---|---|---|
| edu | -0.060 | 0.007 | -9.140 | 0.000 | -0.073 | -0.047 |
| edu2 | 0.009 | 0.000 | 30.520 | 0.000 | 0.009 | 0.010 |
| exp | 0.063 | 0.002 | 39.830 | 0.000 | 0.060 | 0.066 |
| exp2 | -0.001 | 0.000 | -22.990 | 0.000 | -0.001 | -0.001 |
| gend | -0.515 | 0.009 | -55.410 | 0.000 | -0.533 | -0.497 |
| preta | -0.277 | 0.024 | -11.570 | 0.000 | -0.324 | -0.230 |
| parda | -0.214 | 0.011 | -18.600 | 0.000 | -0.236 | -0.191 |
| dun | -0.153 | 0.023 | -6.760 | 0.000 | -0.198 | -0.109 |
| drn | -0.520 | 0.099 | -5.260 | 0.000 | -0.714 | -0.326 |
| dune | -0.408 | 0.018 | -22.390 | 0.000 | -0.443 | -0.372 |
| drne | -0.796 | 0.044 | -18.130 | 0.000 | -0.882 | -0.710 |
| drse | -0.276 | 0.055 | -5.030 | 0.000 | -0.384 | -0.169 |
| dus | -0.146 | 0.017 | -8.600 | 0.000 | -0.179 | -0.113 |
| drs | -0.317 | 0.052 | -6.030 | 0.000 | -0.419 | -0.214 |
| ducw | -0.122 | 0.023 | -5.210 | 0.000 | -0.168 | -0.076 |
| drcw | -0.108 | 0.098 | -1.100 | 0.270 | -0.301 | 0.084 |
| _cons | 5.278 | 0.043 | 122.680 | 0.000 | 5.194 | 5.363 |

Source: Authors' calculations. Note:

| | |
|---|---|
| edu: | years of schooling |
| edu2: | edu squared |
| exp: | age minus schooling |
| exp2: | experience squared |
| gend: | female 1 |
| preta: | black |
| parda: | mixed black |
| nnonrem: | number of non-remunerated household members |
| d*: | regional dummies with r (u) for rural (urban), n north, ne northeast, s south, cw center-west. |

## 7.3 Estimation results, labor market segmentation

**Wage equation for testing segmentation hypothesis (unskilled)**

| | | |
|---|---|---|
| Number of obs | = | 53279177 |
| F( 47, 7228) | = | 1232.3 |
| Prob > F | = | 0 |
| R-squared | = | 0.5021 |
| Root MSE | = | 0.68619 |

| | *Coef.* | *Robust Std. Err.* | *t* | *P>\|t\|* | *[95% Conf.* | *Interval]* |
|---|---|---|---|---|---|---|
| dprim1 | 0.194 | 0.007 | 26.410 | 0.000 | 0.179 | 0.208 |
| dprim2 | 0.343 | 0.008 | 41.420 | 0.000 | 0.327 | 0.359 |
| dprim3 | 0.540 | 0.010 | 55.020 | 0.000 | 0.521 | 0.560 |
| dsec1 | 0.637 | 0.012 | 53.890 | 0.000 | 0.613 | 0.660 |
| dsec2 | 0.878 | 0.011 | 81.940 | 0.000 | 0.857 | 0.899 |
| dter | 1.464 | 0.019 | 78.220 | 0.000 | 1.428 | 1.501 |
| exp | 0.058 | 0.001 | 83.820 | 0.000 | 0.056 | 0.059 |
| exp2 | -0.001 | 0.000 | -69.420 | 0.000 | -0.001 | -0.001 |
| d1 | -0.469 | 0.028 | -16.510 | 0.000 | -0.524 | -0.413 |
| d2 | 0.063 | 0.056 | 1.140 | 0.256 | -0.046 | 0.172 |
| d3 | -0.011 | 0.024 | -0.470 | 0.640 | -0.059 | 0.036 |
| d4 | -0.238 | 0.017 | -13.710 | 0.000 | -0.272 | -0.204 |
| d5 | -0.070 | 0.017 | -4.030 | 0.000 | -0.104 | -0.036 |
| d6 | -0.722 | 0.028 | -26.200 | 0.000 | -0.776 | -0.668 |
| d7 | 0.226 | 0.049 | 4.610 | 0.000 | 0.130 | 0.322 |
| d8 | -0.033 | 0.012 | -2.700 | 0.007 | -0.058 | -0.009 |
| d9 | 0.024 | 0.016 | 1.530 | 0.126 | -0.007 | 0.055 |
| d10 | 0.020 | 0.023 | 0.890 | 0.374 | -0.024 | 0.065 |
| d11 | 0.124 | 0.019 | 6.520 | 0.000 | 0.087 | 0.162 |
| d12 | 0.049 | 0.013 | 3.880 | 0.000 | 0.024 | 0.074 |
| d13 | 0.135 | 0.015 | 9.230 | 0.000 | 0.106 | 0.164 |
| d15 | 0.077 | 0.009 | 8.540 | 0.000 | 0.059 | 0.094 |
| d16 | 0.093 | 0.007 | 13.020 | 0.000 | 0.079 | 0.107 |
| d17 | 0.208 | 0.012 | 18.080 | 0.000 | 0.186 | 0.231 |
| carteira | 0.330 | 0.006 | 57.810 | 0.000 | 0.318 | 0.341 |
| seasonal | -0.125 | 0.017 | -7.260 | 0.000 | -0.158 | -0.091 |
| dse | 0.088 | 0.009 | 9.660 | 0.000 | 0.070 | 0.106 |
| arrend | 0.116 | 0.043 | 2.720 | 0.007 | 0.032 | 0.200 |
| poss | -0.148 | 0.055 | -2.720 | 0.007 | -0.255 | -0.041 |
| cess | -0.278 | 0.041 | -6.760 | 0.000 | -0.359 | -0.198 |
| prop | 0.077 | 0.023 | 3.350 | 0.001 | 0.032 | 0.122 |
| dworkown | -0.138 | 0.021 | -6.670 | 0.000 | -0.179 | -0.097 |
| nnonrem | 0.037 | 0.007 | 5.570 | 0.000 | 0.024 | 0.050 |
| gend | -0.531 | 0.006 | -89.070 | 0.000 | -0.542 | -0.519 |
| preta | -0.144 | 0.010 | -14.800 | 0.000 | -0.163 | -0.125 |
| amarela | 0.310 | 0.054 | 5.740 | 0.000 | 0.204 | 0.415 |
| parda | -0.135 | 0.006 | -22.770 | 0.000 | -0.147 | -0.124 |
| dun | -0.144 | 0.012 | -12.120 | 0.000 | -0.167 | -0.120 |
| drn | -0.312 | 0.044 | -7.010 | 0.000 | -0.399 | -0.225 |
| dune | -0.422 | 0.010 | -40.210 | 0.000 | -0.443 | -0.401 |
| drne | -0.573 | 0.020 | -29.350 | 0.000 | -0.611 | -0.534 |
| drse | -0.223 | 0.021 | -10.730 | 0.000 | -0.264 | -0.182 |
| dus | -0.081 | 0.010 | -7.960 | 0.000 | -0.101 | -0.061 |
| drs | -0.142 | 0.024 | -6.000 | 0.000 | -0.188 | -0.095 |
| ducw | -0.081 | 0.013 | -6.460 | 0.000 | -0.105 | -0.056 |
| drcw | -0.141 | 0.026 | -5.350 | 0.000 | -0.193 | -0.089 |
| isourban2 | -0.081 | 0.049 | -1.660 | 0.098 | -0.178 | 0.015 |
| _cons | 4.461 | 0.017 | 269.920 | 0.000 | 4.429 | 4.493 |

**Wage equation for testing segmentation hypothesis (skilled)**

| | | |
|---|---|---|
| Number of obs | = | 16669698 |
| F( 47, 7228) | = | 357.69 |
| Prob > F | = | 0 |
| R-squared | = | 0.4503 |
| Root MSE | = | 0.75121 |

| | *Coef.* | *Robust Std. Err.* | *t* | *P>\|t\|* | *[95% Conf. Interval]* | |
|---|---|---|---|---|---|---|
| dprim1 | 0.200 | 0.040 | 5.050 | 0.000 | 0.122 | 0.277 |
| dprim2 | 0.239 | 0.038 | 6.290 | 0.000 | 0.165 | 0.314 |
| dprim3 | 0.425 | 0.037 | 11.490 | 0.000 | 0.352 | 0.497 |
| dsec1 | 0.490 | 0.037 | 13.140 | 0.000 | 0.417 | 0.563 |
| dsec2 | 0.766 | 0.035 | 22.190 | 0.000 | 0.698 | 0.834 |
| dter | 1.484 | 0.036 | 41.620 | 0.000 | 1.414 | 1.554 |
| exp | 0.067 | 0.002 | 43.160 | 0.000 | 0.064 | 0.070 |
| exp2 | -0.001 | 0.000 | -26.140 | 0.000 | -0.001 | -0.001 |
| d1 | -0.417 | 0.152 | -2.740 | 0.006 | -0.714 | -0.119 |
| d2 | 0.499 | 0.176 | 2.840 | 0.005 | 0.154 | 0.843 |
| d3 | 0.216 | 0.211 | 1.020 | 0.306 | -0.198 | 0.630 |
| d4 | -0.319 | 0.065 | -4.870 | 0.000 | -0.447 | -0.190 |
| d5 | 0.035 | 0.052 | 0.690 | 0.493 | -0.066 | 0.136 |
| d6 | -0.048 | 0.183 | -0.260 | 0.792 | -0.407 | 0.311 |
| d7 | 0.345 | 0.073 | 4.720 | 0.000 | 0.202 | 0.489 |
| d8 | 0.195 | 0.033 | 5.970 | 0.000 | 0.131 | 0.259 |
| d9 | 0.133 | 0.037 | 3.630 | 0.000 | 0.061 | 0.205 |
| d10 | 0.214 | 0.035 | 6.140 | 0.000 | 0.146 | 0.282 |
| d11 | 0.280 | 0.036 | 7.670 | 0.000 | 0.208 | 0.351 |
| d12 | 0.135 | 0.034 | 3.940 | 0.000 | 0.068 | 0.203 |
| d13 | 0.066 | 0.034 | 1.980 | 0.048 | 0.001 | 0.132 |
| d15 | 0.264 | 0.031 | 8.630 | 0.000 | 0.204 | 0.324 |
| d16 | 0.185 | 0.015 | 12.670 | 0.000 | 0.157 | 0.214 |
| d17 | 0.110 | 0.015 | 7.260 | 0.000 | 0.081 | 0.140 |
| carteira | -0.059 | 0.012 | -4.940 | 0.000 | -0.083 | -0.036 |
| seasonal | -0.705 | 0.213 | -3.320 | 0.001 | -1.122 | -0.289 |
| dse | -0.254 | 0.025 | -10.000 | 0.000 | -0.304 | -0.204 |
| arrend | 0.627 | 0.191 | 3.280 | 0.001 | 0.252 | 1.002 |
| poss | -0.085 | 0.341 | -0.250 | 0.802 | -0.754 | 0.583 |
| cess | -0.014 | 0.230 | -0.060 | 0.952 | -0.465 | 0.437 |
| prop | 0.391 | 0.062 | 6.350 | 0.000 | 0.270 | 0.512 |
| nnonrem | 0.039 | 0.017 | 2.340 | 0.019 | 0.006 | 0.072 |
| gend | -0.473 | 0.009 | -50.400 | 0.000 | -0.492 | -0.455 |
| preta | -0.257 | 0.024 | -10.910 | 0.000 | -0.303 | -0.211 |
| amarela | 0.255 | 0.069 | 3.680 | 0.000 | 0.120 | 0.391 |
| parda | -0.209 | 0.011 | -18.640 | 0.000 | -0.231 | -0.187 |
| dun | -0.168 | 0.022 | -7.470 | 0.000 | -0.212 | -0.124 |
| drn | -0.635 | 0.102 | -6.230 | 0.000 | -0.835 | -0.436 |
| dune | -0.396 | 0.018 | -21.520 | 0.000 | -0.432 | -0.360 |
| drne | -0.784 | 0.040 | -19.360 | 0.000 | -0.863 | -0.704 |
| drse | -0.368 | 0.055 | -6.730 | 0.000 | -0.475 | -0.261 |
| dus | -0.161 | 0.017 | -9.470 | 0.000 | -0.194 | -0.127 |
| drs | -0.414 | 0.055 | -7.580 | 0.000 | -0.521 | -0.307 |
| ducw | -0.153 | 0.023 | -6.510 | 0.000 | -0.199 | -0.107 |
| drcw | -0.224 | 0.096 | -2.330 | 0.020 | -0.413 | -0.035 |
| isourban2 | -0.028 | 0.078 | -0.360 | 0.723 | -0.180 | 0.125 |
| _cons | 5.007 | 0.040 | 123.880 | 0.000 | 4.928 | 5.086 |

Source: Authors' calculations. Note: The grey-shaded dummies are dummies for agricultural sectors.

## 7.4 Poverty lines, in 2001 R$

*Table 23: Regional poverty lines*

| | | |
|---|---|---|
| North | Urban | 87 |
| | Rural | 76 |
| Northeast | Urban | 85 |
| | Rural | 75 |
| Center-West | Urban | 70 |
| | Rural | 62 |
| | Distrito Federal | 82 |
| Southeast | Urban Rio de Janeiro | 80 |
| | Rural Rio de Janeiro | 72 |
| | Urban Sao Paulo | 84 |
| | Rural Sao Paulo | 69 |
| | Urban Minas Gerais and Espirito Santo | 66 |
| | Rural Minas Gerais and Espirito Santo | 57 |
| South | Urban | 83 |
| | Rural | 75 |

Source: Authors' calculations based on Paes de Barros (2004).

## 7.5 Macro model' Sectors

*Table 24: Model-GTAP sector mapping*

| | Model Sectors | GTAP 5 Sectors | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CerealGrains | PDR | WHT | GRO | | | | | |
| 2 | OilSeeds | OSD | | | | | | | |
| 3 | RawSugar | C_B | | | | | | | |
| 4 | OthCrops | V_F | PFB | OCR | WOL | FRS | FSH | | |
| 5 | Livestock | CTL | | | | | | | |
| 6 | RawAnimalProducts | OAP | RMK | | | | | | |
| 7 | OilMinerals | COL | OIL | GAS | OMN | | | | |
| 8 | LightManufacturing | CMT | MIL | PCR | TEX | WAP | | | |
| 9 | AgriIndustriesExp | OMT | VOL | SGR | OFD | LEA | B_T | | |
| 10 | WoodProductsPaper | LUM | PPP | | | | | | |
| 11 | ChemicalsOilPr | P_C | CRP | | | | | | |
| 12 | MetalMineralProducts | NMM | I_S | NFM | FMP | | | | |
| 13 | MachineryEquipment | MVH | ELE | OME | OTN | OMF | | | |
| 14 | OtherServices | GDT | WTR | ELY | OFI | ISR | OBS | ROS | DWE |
| 15 | Construction | CNS | | | | | | | |
| 16 | TradeCommunication | TRD | CMN | OTP | WTP | ATP | | | |
| 17 | PublicServices | OSG | | | | | | | |

*Table 25: GTAP sector labels*

| GTAP 5 Sectors | | | |
|---|---|---|---|
| PDR | Paddy rice | LUM | Wood products |
| WHT | Wheat | PPP | Paper products, publishing |
| GRO | Cereal grains nec | P_C | Petroleum, coal products |
| V_F | Vegetables, fruit, nuts | CRP | Chemical, rubber, plastic products |
| OSD | Oil seeds | NMM | Mineral products nec |
| C_B | Sugar cane, sugar beet | I_S | Ferrous metals |
| PFB | Plant-based fibers | NFM | Metals nec |
| OCR | Crops nec | FMP | Metal products |
| CTL | Bovine cattle, sheep and goats, horses | MVH | Motor vehicles and parts |
| OAP | Animal products nec | OTN | Transport equipment nec |
| RMK | Raw milk | ELE | Electronic equipment |
| WOL | Wool, silk-worm cocoons | OME | Machinery and equipment nec |
| FOR | Forestry | OMF | Manufactures nec |
| FSH | Fishing | ELY | Electricity |
| COL | Coal | GDT | Gas manufacture, distribution |
| OIL | Oil | WTR | Water |
| GAS | Gas | CNS | Construction |
| OMN | Minerals nec | TRD | Trade |
| CMT | Bovine meat products | OTP | Transport nec |
| OMT | Meat products nec | WTP | Water transport |
| VOL | Vegetable oils and fats | ATP | Air transport |
| MIL | Dairy products | CMN | Communication |
| PCR | Processed rice | OFI | Financial services nec |
| SGR | Sugar | ISR | Insurance |
| OFD | Food products nec | OBS | Business services nec |
| B_T | Beverages and tobacco products | ROS | Recreational and other services |
| TEX | Textiles | OSG | Public Administration, Defense, Education, Health |
| WAP | Wearing apparel | DWE | Dwellings |
| LEA | Leather products | | |

*Figure 4: Production nesting*